DOCUMENT RESUME

ED 146 391 CE 013 344

AUTHOR	Wantiez, Gary W.
TITLE	Air Conditioning and Refrigeration. Book Two.
INSTITUTION	Mid-America Vocational Curriculum Consortium, Stillwater, Okla.
SPONS AGENCY	Oklahoma State Dept. of Vocational and Technical Education, Stillwater.
PUB DATE	77
NOTE	783p.; For a related document see CE 013 343
AVAILABLE FROM	Mid-America Vocational Curriculum Consortium, 1515 West Sixth, Stillwater, Oklahoma 74074 ($20.00)
EDRS PRICE	MF-$1.50 Plus Postage. HC Not Available from EDRS.
DESCRIPTORS	*Air Conditioning; *Behavioral Objectives; Curriculum Guides; Job Skills; *Learning Activities; Post Secondary Education; *Refrigeration; *Refrigeration Mechanics; Secondary Education; Skill Development; Unit Plan; Vocational Education

ABSTRACT

This curriculum guide (book II), along with book I, is designed to provide students with the basic skills for an occupation in air conditioning and refrigeration. Six major areas are included, each consisting of one or more units of instruction. These areas and their respective units are titled as follows: Electricity (fundamentals of electricity, electrical test instruments, and electric power), Electrical Components (basic electric thermostats, relays, protection devices, and capacitors), Motors (electric motors, split-phase motors, shaded-pole motors, and three-phase motors), Wiring Diagrams, Domestic Refrigeration (domestic refrigeration fundamentals, sealed system components, domestic refrigeration defrost and electrical controls, mechanical servicing of domestic refrigerators, troubleshooting domestic refrigerators, and domestic refrigerator ice makers), and Window Air Conditioners (fundamentals of window air conditioners and window air conditioner repair). Each unit includes some or all of the following basic components: performance objectives, suggested activities for teacher and students, information sheets (providing content essential for meeting the cognitive objectives of the unit), assignment sheets, job sheets (giving direction to the skill being taught and allowing both student and teacher to check student progress), visual aids, tests, and answers to tests. Units are planned for more than one lesson or class period. Full-page illustrations and diagrams are presented throughout the guide. (SH)

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AIR CONDITIONING AND REFRIGERATION
BOOK TWO

by
Gary W. Wantiez C.M.

Developed by the
Mid-America Vocational Curriculum Consortium, Inc.

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CE 013 344

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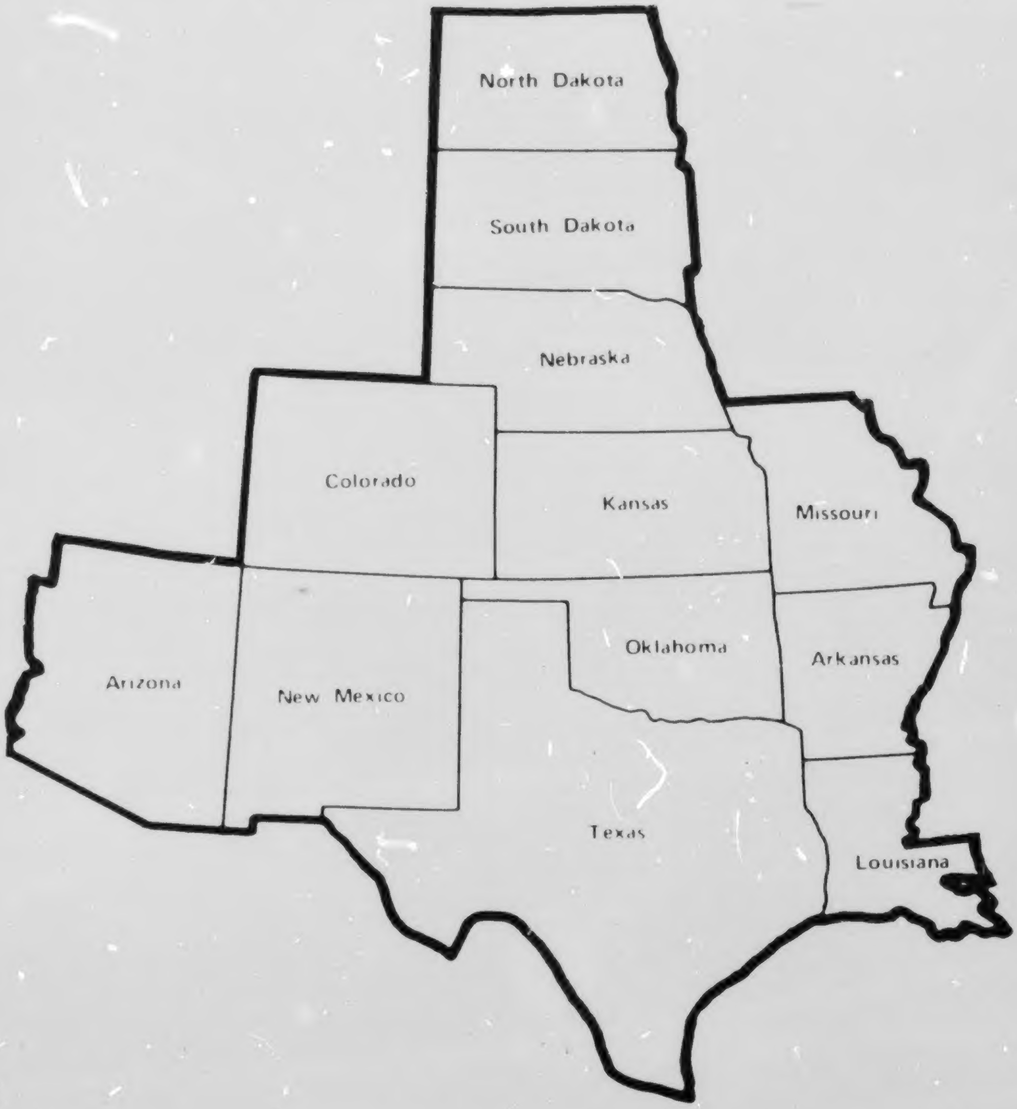
Printed by
State Department of Vocational and Technical Education
Stillwater, Oklahoma 74074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FOREWORD

The Mid-America Vocational Curriculum Consortium (MAVCC) is an organization which consists of twelve states striving to develop needed instructional materials. As member states, Arizona, New Mexico, Colorado, Louisiana, Missouri, Arkansas, Texas, Oklahoma, Kansas, Nebraska, South Dakota, and North Dakota selected Air Conditioning and Refrigeration as one of the early priorities.

The success of this publication is due, in large part, to the capabilities of the personnel who worked with its development. Gary Wantiez, the technical writer, has numerous years of industry as well as teaching experience. Joining him were representatives of each of the states, all of whom having experiences in education and the trade. And, to be sure all of the materials were technically accurate, many organizations were involved. Special appreciation is extended to the National Environmental Systems Contractors Association (NESCA), Associated Builders and Contractors (ABC), Refrigeration Service Engineers Society (RSES), and the Coleman Company.

This publication is designed to assist teachers in improving instruction. As this publication and the three other volumes are used, it is hoped that student performance will improve and that students will be better able to assume a role in an air-conditioning and refrigeration occupation.

Instructional material in this publication is written in terms of student performance using measureable objectives. This is an innovative approach to teaching that accents and augments the teaching-learning process. Criterion referenced evaluation instruments are provided for a uniform measurement of student progress. In addition to evaluating recall information, teachers are encouraged to evaluate the other areas including process and product as indicated at the end of each instructional unit.

It is our belief that the teaching of this area should become more effective with its use.

Don Eshelby, Chairman
Board of Directors
Mid-America Vocational
Curriculum Consortium

PREFACE

The importance of providing every student who is enrolled in an air-conditioning and refrigeration training program with the very best and most complete basic training possible cannot be over emphasized. This second in a series of four publications of the Air-Conditioning and Refrigeration curriculum was developed with the intent of providing the basic skills and knowledge that the student will need as a good foundation from which to build.

As our nation moves into an era of energy conservation and environmental protection, the demands placed upon the air-conditioning and refrigeration specialist become even greater. Indoor environmental control requires an individual who has a very strong foundation in the basics, in order to obtain maximum efficiency from the climate control equipment with a minimum of energy use.

This publication was developed with the assistance of many individuals very knowledgeable in the trade. Some of these individuals represent professional associations and industry. Their assistance and devotion to this project is greatly appreciated. It should be emphasized that the student needs to be made aware of professional trade associations and take an active part in them as much as possible. The professional trade associations are an excellent avenue for continuing education within the trade. Every student, instructor, and all other individuals associated with this trade should develop the attitude of "professionalism" in their endeavors.

Every effort has been made to make this publication basic, readable, and by all means, usable. Three vital parts of instruction have been intentionally omitted from this publication: motivation, personalization, and localization. These areas are left to the individual instructors and the instructors should capitalize on them. Only then will this publication really become a vital part of the teaching-learning process.

Gary W. Wantiez
Writer

Ann Benson
Executive Director

ACKNOWLEDGMENTS

Appreciation is extended to those individuals who contributed their time and talents to the development of *Air Conditioning and Refrigeration, Book Two.*

The contents of this publication were planned and reviewed by:

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Thanks are extended to John J. Derraugh and Al Spriggs, instructors from the Algonquin College of Applied Arts and Technology in Ottawa, Canada.

Special thanks are extended to Dr. Clyde Knight, Trade and Industrial teacher educator from Oklahoma State University and to Richard E. Shepperd, Trade and Industrial teacher educator from Texas A. and I. University at Corpus Christi for their assistance and input into the development of this curriculum.

Gratitude is expressed to Regina Decker and Mary Kellum for editing; to Flo Eubanks and Sandy Thompson for assistance with research; and Teddi Cox and the Graphics Division for typing.

Special appreciation goes to Bob Rea, Media/Graphics Designer; Mike Adair and Jon Dickey, Illustrators, Karen Tout, Paste-Up Artist, for the illustrations and drawings used in this publication.

The printing staff of the Oklahoma State Department of Vocational and Technical Education are deserving of much credit for printing this publication.

USE OF THIS PUBLICATION

Instructional Units

The Air Conditioning and Refrigeration, Book II curriculum includes six areas. Each area consists of one or more units of instruction. Each instructional unit includes some or all of the basic components of a unit of instruction: performance objectives, suggested activities for teacher and students, information sheets, assignment sheets, job sheets, visual aids, tests, and answers to the test. Units are planned for more than one lesson or class period of instruction.

Careful study of each instructional unit by the teacher will help determine:

A. The amount of material that can be covered in each class period.
B. The skills which must be demonstrated.
    1. Supplies needed
    2. Equipment needed
    3. Amount of practice needed
    4. Amount of class time needed for demonstrations
C. Supplementary materials such as pamphlets and filmstrips that must be ordered.
D. Resource people that must be contacted.

Objectives

Each unit of instruction is based on performance objectives. These objectives state the goals of the course thus providing a sense of direction and accomplishment for the student.

Performance objectives are stated in two forms: unit objectives, stating the subject matter to be covered in a unit of instruction and specific objectives, stating the student performance necessary to reach the unit objective.

Since the objectives of the unit provide direction for the teaching-learning process, it is important for the teacher and students to have a common understanding of the intent of the objectives. A limited number of performance terms have been used in the objectives for this curriculum to assist in promoting the effectiveness of the communication among all individuals using the materials.

Following is a list of performance terms and their synonyms which may have been used in this material:

Name
Label
List in writing
List orally
Letter
Record
Repeat
Give

Identify
Select
Mark
Point out
Pick out
Choose
Locate

Describe
Define
Discuss in writing
Discuss orally
Interpret
Tell how
Tell what
Explain

Order
Arrange
Sequence
List in order
Classify
Divide
Isolate
Sort

Distinguish
Discriminate

Construct
Draw
Make
Build
Design
Formulate
Reproduce
Transcribe
Reduce
Increase
Figure

Demonstrate
Show your work
Show procedure
Perform an experiment
Perform the steps
Operate
Remove
Replace
Turn off/on
(Dis) assemble
(Dis) connect

Additional Terms Used
Evaluate
Complete
Analyze
Calculate
Estimate
Plan
Observe
Compare
Determine
Perform

Prepare
Make
Read
Tell
Teach
Converse
Lead
State
Write

Reading of the objectives by the student should be followed by a class discussion to answer any questions concerning performance requirements for each instructional unit.

Teachers should feel free to add objectives which will fit the material to the needs of the students and community. When teachers add objectives, they should remember to supply the needed information, assignment and/or job sheets, and criterion tests.

Suggested Activities

Each unit of instruction has a suggested activities sheet outlining steps to follow in accomplishing specific objectives. The activities are listed according to whether they are the responsibility of the instructor or the student.

Instructor: Duties of the instructor will vary according to the particular unit; however, for best use of the material they should include the following: provide students with objective sheet, information sheet, assignment sheets, and job sheets; preview filmstrips, make transparencies and arrange for resource materials and people; discuss unit and specific objectives and information sheet; give test. Teachers are encouraged to use any additional instructional activities and teaching methods to aid students in accomplishing the objectives.

Students: Student activities are listed which will help the student to achieve the objectives for the unit.

Information Sheets

Information sheets provide content essential for meeting the cognitive (knowledge) objectives of the unit. The teacher will find that information sheets serve as an excellent guide for presenting the background knowledge necessary to develop the skills specified in the unit objective.

Students should read the information sheets before the information is discussed in class. Students may take additional notes on the information sheets.

Transparency Masters

Transparency masters provide information in a special way. The students may see as well as hear the material being presented, thus reinforcing the learning process. Transparencies may present new information or they may reinforce information presented in the information sheets. They are particularly effective when identification is necessary.

Transparencies should be made and placed in the notebook where they will be immediately available for use. Transparencies direct the class's attention to the topic of discussion. They should be left on the screen only when topics shown are under discussion.

Job Sheets

Job sheets are an important segment of each unit. The instructor should be able to and in most situations should demonstrate the skills outlined in the job sheets. Procedures outlined in the job sheets give direction to the skill being taught and allow both student and teacher to check student progress toward the accomplishment of the skill. Job sheets provide a ready outline for a student to follow if he has missed a demonstration. Job sheets also furnish potential employers with a picture of the skills being taught and the performances he might reasonably expect from a person who has had this training.

Assignment Sheets

Assignment sheets give direction to study and furnish practice for paper and pencil activities to develop the knowledges which are necessary prerequisites to skill development. These may be given to the student for completion in class or used for homework assignments. Answer sheets are provided which may be used by the student and/or teacher for checking student progress.

Test and Evaluation

Paper-pencil and performance tests have been constructed to measure student achievement of each objective listed in the unit of instruction. Individual test items may be pulled out and used as a short test to determine student achievement of a particular objective. This kind of testing may be used as a daily quiz and will help the teacher spot difficulties being encountered by students in their efforts to accomplish the terminal objective. Test items for objectives added by the teacher should be constructed and added to the test.

Test Answers

Test answers are provided for each unit. These may be used by the teacher and/or student for checking student achievement of the objectives.

AIR CONDITIONING AND REFRIGERATION
BOOK TWO

OCCUPATIONAL/INSTRUCTIONAL ANALYSIS

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)

SECTION A--UNIT I: FUNDAMENTALS OF ELECTRICITY

1. Distinguish between direct and alternating current
2. List materials which are good conductors of electricity
3. List materials which are good insulators of electricity
4. List the equation symbols and equations for ohm's law
5. List three equations for obtaining wattage
6. List three common conversions of wattage
7. List the three items that make a complete electrical circuit
8. Match terms to correct basic electrical symbols
9. Identify a series circuit
10. State four rules for series circuits
11. Identify a parallel circuit

JOB TRAINING: What the Worker Should Be able to Do (Psychomotor)

RELATED INFORMATION: What the Worker Should Know (Cognitive)

12. State three rules for a parallel circuit

13. Identify a series-parallel circuit

14. Match amperage loads to wire sizes

15. Use ohm's law

16. Compute wattage

17. Select the nonseries loads

18. Solder an electrical connection

UNIT II: ELECTRICAL TEST INSTRUMENTS

1. List eleven safety rules pertaining to electrical test meters

2. List general rules for the protection of electrical test meters

3. Identify electrical test instruments

4. Match the meter to its application

5. List the procedure for reading a meter scale

6. Discuss three circuit conditions

7. Describe the procedure for zeroing the ohmmeter

8. Read a voltmeter scale

9. Read an ammeter scale

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
10. Read an ohmmeter scale	
11. Determine start, run and common of a single phase motor	
12. Use a voltmeter	
13. Use an ohmmeter	
14. Use a wattmeter	
15. Use an ammeter	
16. Use the hermetic analyzer	
17. Use a capacitor analyzer	
18. Test a capacitor with an ohmmeter	
UNIT III: ELECTRIC POWER	
	1. Arrange in order the steps for distributing electric power
	2. Distinguish between single-phase and three-phase currents
	3. List three methods of grounding an electrical circuit
	4. Select the functions of a transformer
	5. Discuss the types of three-phase supply
6. Read an electric watt-hour meter	
SECTION B-UNIT I: BASIC ELECTRIC THERMOSTATS	
	1. Name three types of thermostats

JOB TRAINING: What the Worker Should Be Able to Do
(Psychomotor)

14. Wire a mercury bulb to correct terminals

RELATED INFORMATION: What the Worker Should Know
(Cognitive)

2. Identify parts of a low voltage thermostat

3. Identify parts of a millivolt thermostat

4. Identify parts of a line voltage thermostat

5. Identify types of thermostat contacts

6. Identify shapes of thermostatic bimetals

7. Discuss the operation of a thermostatic bimetal

8. Discuss thermostat anticipation

9. List the characteristics of two-stage thermostat

10. Discuss the advantages of a time controlled thermostat

11. Select from a list guidelines for correctly installing a room thermostat

12. List the applications of low voltage, millivolt, and line voltage thermostats

13. Match the low voltage thermostat subbase terminal markings to the proper component

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
15. Determine heat anticipation	
16. Install a wall thermostat	

UNIT II. RELAYS

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
	1. Identify motor starting relays
	2. Identify control relay switching symbols
	3. Match the components to the correct relay terminal markings that they connect to
	4. List the specifications of motor relays
	5. List the specifications of a contactor
	6. Discuss the characteristics and types of time delay relays
	7. Draw the connecting wiring of a hot wire relay
	8. Draw the connecting wiring of a current relay
	9. Draw the connecting wiring of a potential relay
	10. Draw the connecting wiring of a fan relay
	11. Draw the connecting wiring of a contactor
12. Wire a hot wire relay	

JOB TRAINING: What the Worker Should Be Able to Do
(Psychomotor)

RELATED INFORMATION: What the Worker Should Know
(Cognitive)

13. Wire a current relay
14. Wire a potential relay
15. Wire a fan relay
16. Check relays with an ohmmeter
17. Check relays with a voltmeter
18. Check relays with an ammeter

UNIT III: PROTECTION DEVICES

1. Identify types of overcurrent protection devices
2. Describe the operation of a single element fuse
3. Describe the operation of a time delay fuse
4. Describe the operation of a circuit breaker
5. List national electrical code requirements pertaining to fuses for less than 600v
6. List four national electrical code requirements pertaining to circuit breakers for less than 600v
7. Identify the types of pressure actuated protection devices
8. Describe the pressure actuated protection devices
9. Identify the types of electrical system protection devices
10. Describe the electrical system protection devices

JOB TRAINING: What the Worker Should Be Able to Do
(Psychomotor)

11. Adjust a high pressure switch
12. Adjust a low pressure switch
13. Install a lockout relay
14. Check a solid-state compressor motor protector

RELATED INFORMATION: What the Worker Should Know
(Cognitive)

UNIT IV: CAPACITORS

1. Discuss the role of capacitors in the operation of motors
2. Identify the types of capacitors
3. Discuss the run capacitor identified terminal
4. List the causes of capacitor failure
5. List the factors to consider when replacing capacitors
6. Solve problems for capacitors wired in series and parallel using the formulas given
7. Draw connecting wiring for a start capacitor with a current relay and a start capacitor with a hot wire relay
8. Draw connecting wiring for a start capacitor with a potential relay
9. Draw connecting wiring for a run capacitor with a permanent split capacitor compressor motor

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
	10. Draw connecting wiring for capacitors with a capacitor start capacitor run compressor motor
11. Wire a start capacitor with a current or hot wire relay	
12. Wire a start capacitor with a potential relay	
13. Wire a run capacitor with a P.S.C. compressor motor	
14. Wire a run capacitor with a C.S.C.R. compressor motor	
15. Determine microfarad rating of a capacitor	
SECTION C--UNIT I: INTRODUCTION TO ELECTRIC MOTORS	
	1. List safety rules pertaining to working with electric motors
	2. Discuss magnetism
	3. Discuss magnets in an induction type motor
	4. List five types of single-phase motors
	5. Identify parts of an open motor
	6. Identify the common types of motor mounts
	7. Discuss motor enclosures
	8. Discuss three-phase motors

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
	9. List the information provided on a motor data plate
	10. Identify the types of motor V-pulleys
	11. Solve problems using a method for determining pulley size
	12. List causes of motor problems
	13. List remedies of motor problems
14. Determine length of a V-belt	
15. Adjust V-belt tension	

UNIT II: SPLIT-PHASE MOTORS

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
	1. State the horsepower range of split-phase motors
	2. List applications of split-phase motors
	3. List the two windings of a split-phase motor
	4. List the characteristics of the windings in a split-phase motor
	5. Discuss the purpose of the starting switch
	6. Identify the components of a split-phase motor
	7. Identify the split-phase motor leads by NEMA's code

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
	8. Match code number to color code of motor leads
	9. Identify the directions of rotation
	10. Identify the motor power wirings
11. Wire a split-phase motor to a 240 VAC supply	
12. Disassemble, inspect, clean, and reassemble a split-phase motor	

UNIT III: SHADED-POLE MOTORS

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
	1. List five applications of shaded-pole motors
	2. Discuss the stator construction of the shaded-pole motor
	3. Match number of poles to the correct motor RPM
	4. List two disadvantages of shaded-pole motors
	5. List the voltages for shaded-pole motors
	6. Discuss the methods of reversing rotation of shaded-pole motors
	7. Discuss the methods of varying the speed in shaded-pole motors
	8. State the most common remedy of shaded-pole motor failure

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
UNIT IV: CAPACITOR MOTORS	
	1. List two types of capacitor motors
	2. Discuss the characteristics of capacitor motors
	3. Discuss C.S.I.R. motors
	4. Discuss C.S.R. motors
	5. Discuss P.S.C. motors
	6. Identify the wiring diagrams of C.S.I.R., C.S.R., and P.S.C. motors
7. Reverse the rotation of a P.S.C. motor	
8. Start a seized hermetic compressor motor	
UNIT V: THREE-PHASE MOTORS	
	1. List the three major types of three-phase motors
	2. Discuss the electrical characteristics of a three-phase motor
	3. Distinguish between a symbolic drawing of a delta wound motor and a symbolic drawing of a wye "Y" wound motor
	4. Discuss the synchronous motor
	5. Discuss the squirrel-cage motor

JOB TRAINING: What the Worker Should Be Able to Do
(Psychomotor)

RELATED INFORMATION: What the Worker Should Know
(Cognitive)

6. Discuss the wound-rotor motor

7. Describe the procedure of reversing the rotation of a three-phase motor

SECTION D--UNIT I: WIRING DIAGRAMS

7. Draw a basic ladder schematic

8. Draw current relay wiring diagrams

9. Draw potential relay wiring diagrams

10. Draw hot-wire relay wiring diagrams

11. Draw gas furnace wiring diagrams

12. Draw outdoor condensing unit wiring diagrams

13. Draw electric furnace wiring diagrams

14. Draw indoor air handler and outdoor condensing unit wiring diagram

15. Draw a domestic refrigerator wiring diagram

16. Draw a ladder schematic by looking at a domestic refrigerator

1. Identify wiring diagrams

2. List the characteristics of a pictorial wiring diagram

3. List the characteristics of a schematic wiring diagram

4. List the major steps in building a ladder schematic

5. Discuss the schematic legend

6. Match schematic symbols to component name

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)

RELATED INFORMATION: What the Worker Should Know (Cognitive)

17. Draw a ladder schematic by looking at a window air conditioner

18. Draw a ladder schematic by looking at a system with a low voltage control circuit

SECTION E--UNIT I: DOMESTIC REFRIGERATION FUNDAMENTALS

1. Identify types of domestic refrigeration

2. Identify refrigerator cabinet hardware and trim

3. List information given on a refrigerator data plate

4. List three common locations of refrigerator data plates

5. List two major reasons why a refrigerator should be transported upright

6. List six common domestic refrigerator problems

7. Remove and replace breaker trim

8. Adjust a door

UNIT II: SEALED SYSTEM COMPONENTS

1. List the sealed system components of a domestic refrigerator

2. Discuss the function of the sealed system components in a domestic refrigerator

3. Identify types of evaporators

4. List the locations of evaporators

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
	5. Identify types of compressors
	6. Identify types of condensers
	7. List the locations of condensers
	8. List the information needed when replacing a capillary tube
9. Replace a compressor motor	
10. Install a low side service stub on a reciprocal compressor	
11. Install service stubs in refrigerant lines	
12. Replace a capillary tube	
13. Install a liquid line filter-drier	

UNIT III: DOMESTIC REFRIGERATION DEFROST AND ELECTRICAL CONTROLS

JOB TRAINING	RELATED INFORMATION
	1. List eight domestic refrigerator heaters
	2. Discuss location of heaters
	3. Discuss the purpose of refrigerator heaters
	4. Identify electrical controls
	5. Discuss location of electrical controls
	6. Discuss hot gas defrost components
	7. Discuss electric defrost components
	8. List two off cycle defrost components

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
9. Name the heater circuits	
10. Name the controls	
11. Diagnose circuit problems	
12. Replace a temperature control	
13. Replace a defrost heater	
UNIT IV: MECHANICAL SERVICING OF DOMESTIC REFRIGERATORS	
	1. List three types of leak detectors
	2. Discuss the indications of a refrigerant leak
	3. List three common mechanical system failures
	4. Discuss the characteristics of a compressor with defective valves
	5. Discuss the characteristics of a restricted capillary tube
	6. List the characteristics of an overcharged system
	7. Discuss compressor burn out
	8. List the steps in cleaning a system after burn out
9. Repair an evaporator with epoxy	
10. Evacuate and charge a refrigerator which has only a low side service valve	

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
11. Evacuate and charge a refrigerator which has only a high side service valve	
12. Clean a system after burn out	
13. Clean a restricted capillary tube	
14. Repair an evaporator by aluminum brazing	
15. Check efficiency of a compressor	

UNIT V: TROUBLESHOOTING DOMESTIC REFRIGERATORS

	1. List the steps in a systematic approach to troubleshooting
	2. List the preliminary checks to be made when troubleshooting a refrigerator
	3. List the steps in checking a nonoperative compressor
	4. Discuss the procedure in troubleshooting a frost-free refrigerator
5. Demonstrate the ability to diagnose refrigerator complaints	

UNIT VI: DOMESTIC REFRIGERATOR ICE MAKERS

	1. Identify three types of ice makers
	2. Identify the pictorial and schematic wiring diagrams for each of the three types of ice makers

JOB TRAINING. What the Worker Should Be Able to Do
(Psychomotor)

13. Install a refrigerator equipped with an ice maker

14. Disassemble and clean a water fill valve

15. Replace thermostat in a crescent shape cube ice maker

RELATED INFORMATION: What the Worker Should Know
(Cognitive)

3. Discuss the operation of the crescent shaped cube ice maker

4. Identify the parts of a crescent shaped cube ice maker

5. Match the problem of the crescent shaped cube ice maker to the checks and remedies

6. Discuss the operation of the five cavity ice maker

7. Identify the parts of the five cavity ice maker

8. Match the problem of the five cavity ice maker to the correct remedies or checks

9. Discuss operation of the flex tray ice maker

10. Identify the parts of the flex tray ice maker

11. Match the problem of the flex tray ice maker to the correct remedies

12. Identify water valves and their components

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)

RELATED INFORMATION: What the Worker Should Know (Cognitive)

16. Replace mold seal, bearing and retainer in a five cavity ice maker

17. Adjust water valve switch in a flex tray ice maker

18. Replace mold heater in a crescent shape cube ice maker

SECTION F--UNIT I: FUNDAMENTALS OF WINDOW AIR CONDITIONERS

1. List the five functions of an air conditioner
2. Identify window air conditioner cabinet parts
3. Identify window air conditioner parts
4. Match electrical receptacle design to voltage and amperage requirements
5. Match wire size to current carrying capacity
6. Identify parts of the window
7. List the procedure for installing a window air conditioner
8. Discuss major components of window air conditioners

9. Install a window air conditioner

UNIT II: WINDOW AIR CONDITIONER REPAIR

1. List the information given on a window air conditioner data plate

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
	2. Discuss compressor data plates
	3. Identify schematic components
	4. Match window air conditioner problems to remedies and checks
5. Check control switch with an ohmmeter	
6. Clean a condenser	
7. Replace a fan motor	
8. Install a hard start kit	

TOOLS

(NOTE: These are the recommended tools and equipment necessary for an air-conditioning and refrigeration training program.)

Screwdrivers
1. Standard slot
2. Phillips
3. Clutch head
4. Stubby
5. Offset

Wrenches
1. Open end
2. Box end
3. Combination
4. Adjustable open end
5. Pipe
6. Flare nut

Pliers
1. Slip joint
2. Slip groove
3. Long nose
4. Diagonal cutters
5. Plier wrench
6. Pinch-off

Hammers
1. Ball peen
2. Soft face
3. Sledge
4. Claw

Punches, Chisels, and Bars
1. Pin punch
2. Center punch
3. Flat chisel
4. Pry bar
5. Scratch awl

Files
1. Flat
2. Half round
3. Round
4. Point
5. Slim taper
6. Handle

Socket sets
1. Ratchet handle
2. Socket
3. Deep socket
4. Hinge handle
5. Extension
6. Speed handle
7. Universal joint

Tubing tools
1. Flaring tool
2. Tubing reamer
3. Flaring block
4. Cutter
5. Double flare punch
6. Swage punch
7. Lever type bender
8. Bending spring

Accessory hand tools
1. Wire strippers
2. Drop light
3. Oil can
4. Hack saw
5. Screw starter
6. Safety glasses
7. Nut drivers
8. Level
9. Hex-key wrenches

Threading tools
1. Tap
2. Die
3. Die stock
4. T-Handle tap wrench
5. Hand tap wrench

Refrigeration gauge sets

Leak detectors
1. Soap solution
2. Halide torch
3. Electronic

Drill motors
1. Straight
2. Offset

Drill bits
1. Twist
2. Wood
3. Masonry

Bench grinders

Vises
1. Bench
2. Pipe

Pullers
1. Wheel
2. Bearing
3. Gear

Thermometers
1. Pocket
2. Remote bulb
3. Flue and stack
4. Thermal electric

Recording thermometers
1. Manual wind
2. Electric

Hygrometers
1. Sling-psychrometers
2. Dial type
3. Humidity recorders

Vacuum pumps
1. Low vacuum
2. Deep vacuum

Vacuum indicators
1. Compound gauge
2. Mercury manometer
3. Thermocouple micron gauge

Capillary tube cleaner
1. Manual type
2. Hydraulic type

Charging cylinders

Service valves
1. Hermetic service valve kit
2. Access valves (core type)
3. Process tube adapters
4. Line piercing valves

Scales

Fin combs

Oil pump

Combustion testing kit

Air meters
1. Aneometer
2. Pitot tube
3. Inclined manometer

Appliance truck

Knock-out cutter

Combination pattern snips

Hand notcher

Hand seamer

Riveter

Riveting hammer

Aviation snips
1. Right hand
2. Left hand

Double cut snips

Hand crimper

Refrigeration ratchets

Air-propane torch
- Torch handle
- Regulator
- High temperature wraparound flame tip
- Standard tips
  1. Small
  2. Medium
  3. Large
- Halide leak detector
- Soldering copper
- Liquified petroleum cylinders
  1. 2 1/2 lb capacity
  2. 20 lb capacity
- Hose--B size with left hand nuts
- Striker

Air-acetylene torch
- Torch handle
- Regulator
- Hose
- Tips
  1. No. 1--Very fine pointed flame
  2. No. 2--Fine
  3. No. 3--Medium
  4. No. 4--Medium large
  5. No. 5--Large
  6. No. 6--Extra large
- High temperature wraparound flame tip
- Halide leak detectors
- Soldering copper
- Acetylene tanks
  1. "B" tank, 40 cubic foot
  2. "MC" tank, 10 cubic foot
- Striker
- Cylinder wrench

Oxyacetylene torch
1. Oxygen regulator
2. Acetylene regulator
3. Torch handle
4. Cutting attachment
5. Welding tip
6. Cutting tip
7. Twin hose
8. Goggles
9. Striker
10. Cart
11. Oxygen cylinder
12. Acetylene cylinder

Electric welder and equipment
1. Electric welder
2. Electrode holder
3. Ground clamp
4. Shield
5. Gloves
6. Chipping hammer
7. Safety goggles
8. Wire brush
9. Electrode

Electrical test instruments
1. Voltmeter
2. Ohmmeter
3. Multimeter
4. Wattmeter
5. Ammeter
6. Millivoltmeter
7. Hermetic analyzer
8. Capacitor analyzer

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FUNDAMENTALS OF ELECTRICITY
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to match terms associated with electricity to correct definitions, and list materials which are good insulators and conductors of electricity. The student should be able to distinguish between a series circuit, a parallel circuit, a series-parallel circuit. The student should also be able to use ohm's law to calculate voltage, current, and resistance, and compute wattages. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with electricity to the correct definitions.
2. Distinguish between direct and alternating current.
3. List materials which are good conductors of electricity.
4. List materials which are good insulators of electricity.
5. List the equation symbols and equations for ohm's law.
6. List three equations for obtaining wattage.
7. List four common conversions of wattage.
8. List the three items that make a complete electrical circuit.
9. Match terms to correct basic electrical symbols.
10. Distinguish between a series, parallel, and series-parallel circuit.
11. State four rules for series circuits.
12. State three rules for a parallel circuit.
13. Match amperage loads to wire sizes.
14. List items of concern when working with solid state controls.

15. Demonstrate the ability to:

    a. Use ohm's law.

    b. Compute wattage.

    c. Select the parallel loads.

    d. Solder electrical wire.

FUNDAMENTALS OF ELECTRICITY
UNIT I

SUGGESTED ACTIVITIES

I. Instructor:

  A. Provide student with objective sheet.

  B. Provide student with information, assignment, and job sheets.

  C. Make transparencies.

  D. Discuss unit and specific objectives.

  E. Discuss information, assignment, and job sheets.

  F. Show students charts, films, and other supplementary material on electrical fundamentals.

  G. Show students how to calculate problems.

  H. Give test.

II. Student:

  A. Read objective sheet.

  B. Study information sheet.

  C. Complete assignment and job sheets.

  D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

  A. Objective sheet

  B. Informati[illegible]eet

  C. Transparency masters

    1. TM 1--Memory Aid for Ohm's Law

    2. TM 2--Symbols

    3. TM 3--Symbols (Continued)

4. TM 4--Series Circuit
5. TM 5--Parallel Circuit
6. TM 6--Series-Parallel Circuit

D. Assignment sheets

1. Assignment Sheet #1--Use Ohm's Law
2. Assignment Sheet #2--Compute Wattage
3. Assignment Sheet #3--Select the Parallel Loads

E. Answers to assignment sheets

F. Job Sheet #1--Solder Electrical Wire

G. Test

H. Answers to test

II. References:

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FUNDAMENTALS OF ELECTRICITY
UNIT I

INFORMATION SHEET

I. Terms and definitions

- A. Electrons--Negatively charged particles
- B. Solid state--Electrical circuit containing semiconductors
- C. Conductor--Any material with the ability to permit passage of electrical current
- D. Insulator--Material with an extremely high resistance to current flow
- E. Voltage (EMF)--Potential difference which causes current to flow
- F. Current--Flow of electrons through a conductor measured in amperes
- G. Resistance--Opposition to current flow measured in ohm
- H. Watt--Unit of power measurement
- I. Inductance--Property in an electrical circuit which opposes any change in the existing current
- J. Capacitance--Factor in an electrical circuit that allows for the storage of electrical charges and opposes any change in existing voltage
- K. Impedance--Total opposition in an electrical circuit to the flow of alternating current
- L. Power factor-Ratio of true power to apparent power required
- M. Semiconductor--Conductor which has a resistance value in between a good conductor and an insulator

  (NOTE: Within limits, the conductance will increase with temperature decrease.)
- N. Counter EMF--Voltage induced in a conductor which is moving through a magnetic field in opposition to the source voltage

  (NOTE: This is a generator action developed within every motor.)
- O. Hertz (cycle)--One complete reversal of an alternating current from positive to negative and back to the starting point in one second
- P. Parallel circuit--Current has more than one path it can take

INFORMATION SHEET

Q. Series circuit--Current has only one path it can take

R. Series-parallel circuit--Electrical circuit consisting of both series and parallel components

S. Branch--That portion of a total circuit which is independent of other portions with each receiving full supply voltage

(NOTE: A circuit may have several branches parallel to each other.)

T. Low line voltage--Decrease in voltage available to a power consuming device

U. Load--Power consuming device

II. Direct and alternating current

A. Direct current

1. Supplied by

a. Generator

b. Battery

1) Dry cell

2) Wet cell

2. Flows in one direction only

3. Abbreviated as DC

B. Alternating current

1. Supplied by an alternating current generator (alternator)

2. Flows in one direction then reverses and flows in the opposite direction

3. Abbreviated as AC

III. Conductors of electricity

A. Silver

(NOTE: Silver has the least resistance to current flow.)

B. Copper

C. Gold

D. Aluminum

INFORMATION SHEET

E. Tungsten

F. Zinc

G. Brass

H Platinum

I. Iron

J. Nickel

K. Tin

L. Steel

M. Lead

N. Mercury

O. Nichrome

(NOTE: Nichrome has the highest resistance to current flow.)

P. Air

Q. Water

(NOTE: Air will conduct electricity under certain humidity conditions, and water will conduct electricity when it contains certain trace minerals.)

IV. Insulators of electricity

A. Glass

B. Rubber

C. Plastic

D. Wood

E. Ceramic

F. Mica

V. Ohm's law

A. Establishes a mathematical relationship between:

1. Potential (voltage)

(NOTE: This is electromotive force (EMF), also called electrical pressure.)

INFORMATION SHEET

2. Current flow (amperage)
3. Resistance (ohms)

B. Equation symbols

1. E = Potential measured in volts
2. I = Current flow measured in amperes
3. R = Resistance measured in ohms

C. Equations (Transparency 1)

1. $E = I \times R$
2. $I = E/R$
3. $R = E/I$

VI. Watts law for DC power

(NOTE: This law also works for AC resistive circuits such as electric heaters.)

A. Establishes a mathematical basis for the amount of work done

(NOTE: The amount of wattage is the basis of the electric bill.)

B. Equations for obtaining wattage

(NOTE: P is the letter symbol for power measured in watts.)

1. $P = E \times I$
2. $P = I^2 \times R$
3. $P = E^2/R$

VII. Common conversions of wattage

A. 1,000 watts = 1 kilowatt (kw)

B. 1,000,000 watts = 1 megawatt

C. 746 watts = 1 horsepower (hp)

D. 1 watt-hour = 3.413 b.t.u.'s

INFORMATION SHEET

VIII. Components of a complete electrical circuit

A. Power source

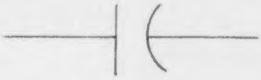
B. Connecting wiring

C. Load

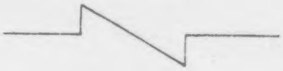
(NOTE: A fourth item is often added to this list which is a switch or control.)

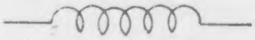
IX. Electrical symbols (Transparency 2)

A. Capacitor

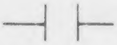


B. Coils

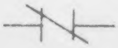




C. Contacts

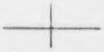


Normally Open (N.O.)

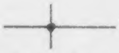


Normally Closed (N.C.)

D. Conductors

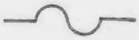


Crossing

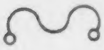


Junction

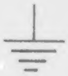
E. Fuse



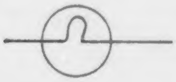
F. Fusible link



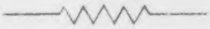
G. Ground connection



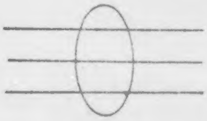
H. Light



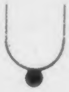
I. Resistor or resistance heater



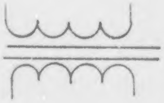
J. Multiple conductor cable



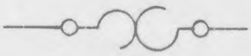
K. Thermocouple



L. Transformer

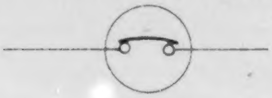


M. Thermal overload

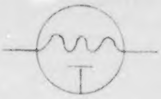


INFORMATION SHEET

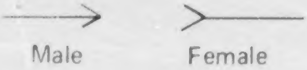
N. Bimetal switch



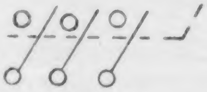
O. Thermistor



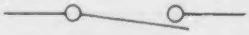
P. Connectors



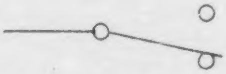
Q. Switches disconnect



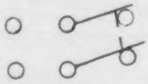
R. Single pole single throw (SPST)



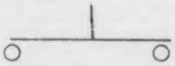
S. Single pole double throw (SPDT)



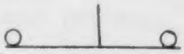
T. Double pole double throw (DPDT)



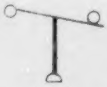
U. Push button (normally open)



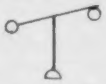
V. Push button (normally closed)



W. Pressure switches

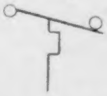


Opens on Pressure Rise

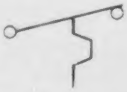


Opens on Pressure Drop

X. Temperature switch

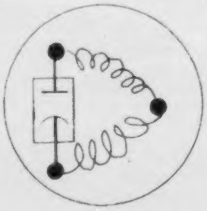


Close on Rise

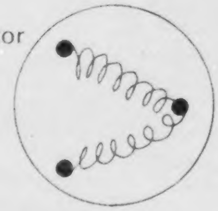


Open on Rise

Y. Permanent split capacitor motor

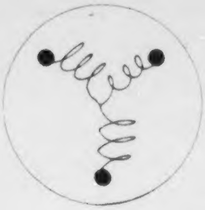


Z. Single-phase motor



INFORMATION SHEET

AA. Three-phase motor



X. Series, parallel, and series-parallel circuits

   A. Series circuit (Transparency 3)

   B. Parallel circuit (Transparency 4)

   C. Series-parallel circuit (Transparency 5)

XI. Rules for series circuits

   A. The current is the same throughout the circuit

   B. The sum of the voltage drops around a series circuit will equal the supply voltage

   C. The largest voltage drop occurs in the component with the highest resistance

   D. The sum of the resistances of the components equals the total resistance

XII. Rules for parallel circuits

   A. Total current equals the sum of the current in all branches

   B. Voltage is the same across all branches

   C. Total resistance is always less than the smallest branch resistance

INFORMATION SHEET

XIII. Amperage loads and wire sizes

GENERAL PURPOSE

Wire Size AWG	Allowable Capacity Amps.	Maximum Motor Size Horse Power		
		Single Phase		3 Phase
		115V	230V	230V
14	15	3/4	2	3
12	20	1	3	5
10	30	2	3	7-1/2
8	40	3	5	10
6	55	3	7-1/2	15
4	70	5	10	20

(NOTE: AWG stands for American Wire Gauge.)

XIV. Items of concern when working with solid state controls

A. Run electronic signal wiring in shielded cable or metallic conduit to avoid electrically noisy locations

Example: Fluorescent lights, commutating switches, strong alternating field motors

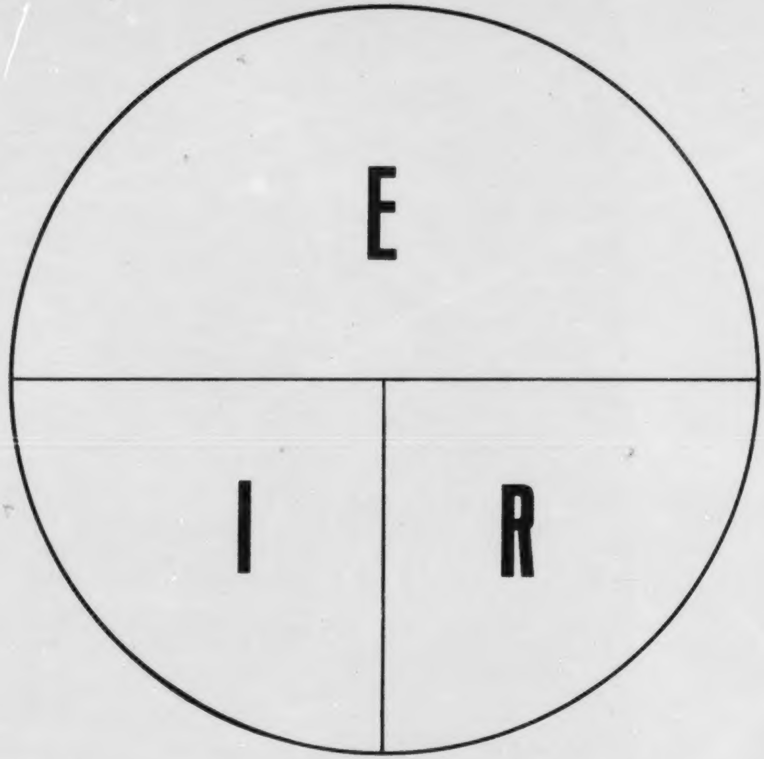
B. Voltage surge

C. Replaceable modules for field repair

(NOTE: The warranty on most solid state controls is void if the cover has been removed for field repair.)

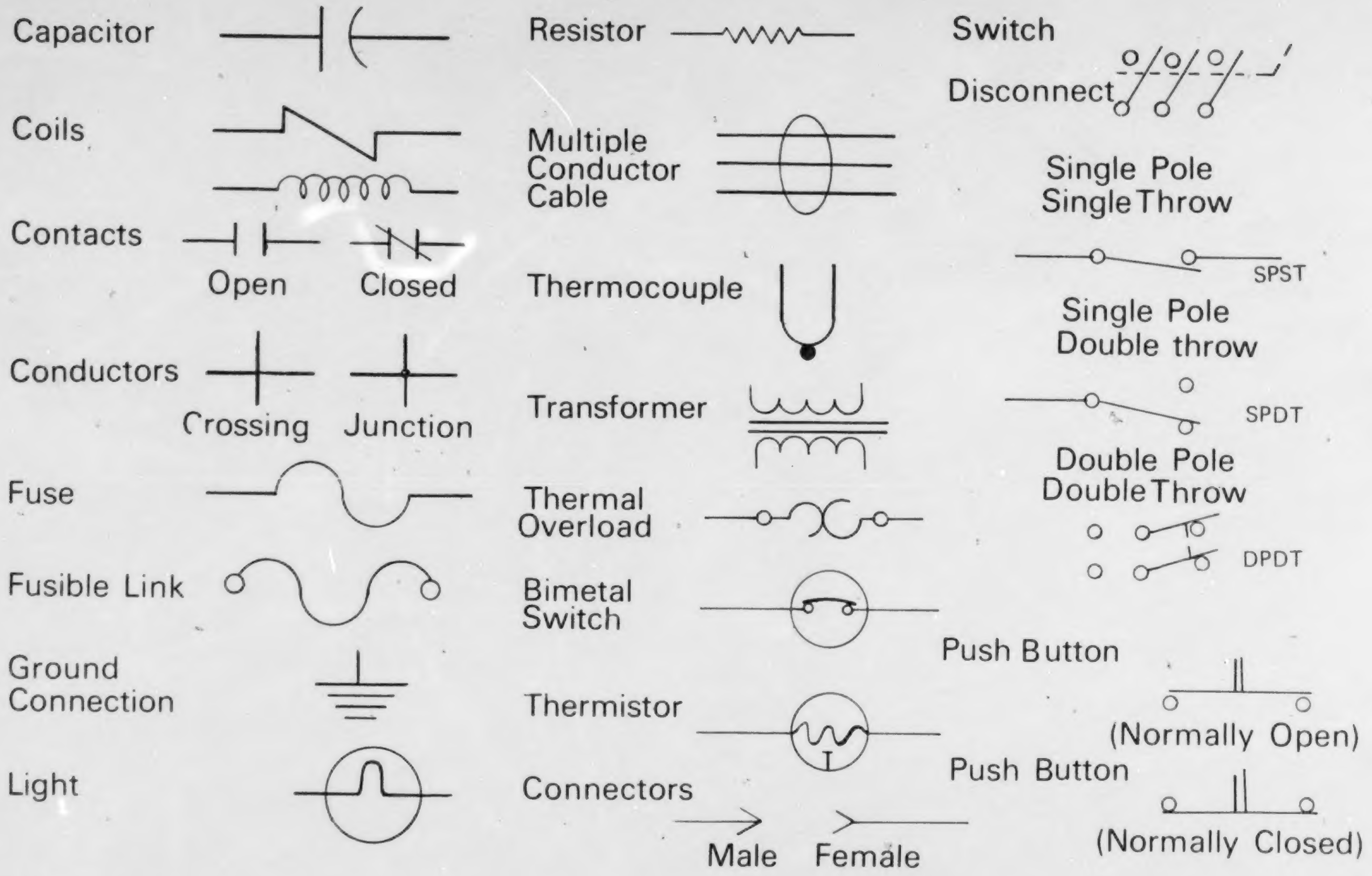
D. Exposure to excessively high temperature will damage solid state devices

Memory Aid For Ohm's Law



TM 1

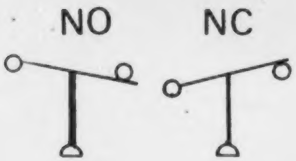
Symbols


Capacitor
Coils
Contacts
Open
Closed
Conductors
Crossing
Junction
Fuse
Fusible Link
Ground Connection
Light
Resistor
Multiple Conductor Cable
Thermocouple
Transformer
Thermal Overload
Bimetal Switch
Thermistor
Connectors
Male
Female
Switch
Disconnect
Single Pole Single Throw
SPST
Single Pole Double throw
SPDT
Double Pole Double Throw
DPDT
Push Button
(Normally Open)
Push Button
(Normally Closed)

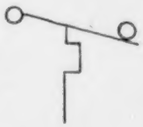
Symbols

(Continued)

Pressure

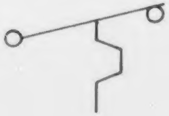


Temperature

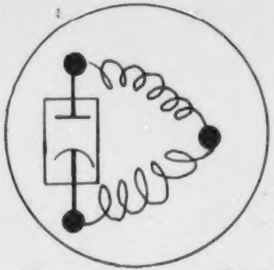


Close on Rise

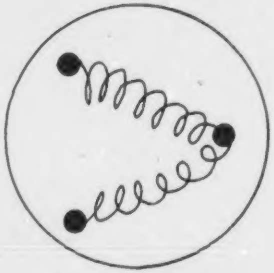
Temperature



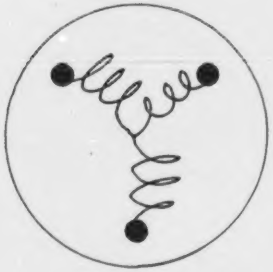
Open on Rise



Permanent Split
Capacitor Motor

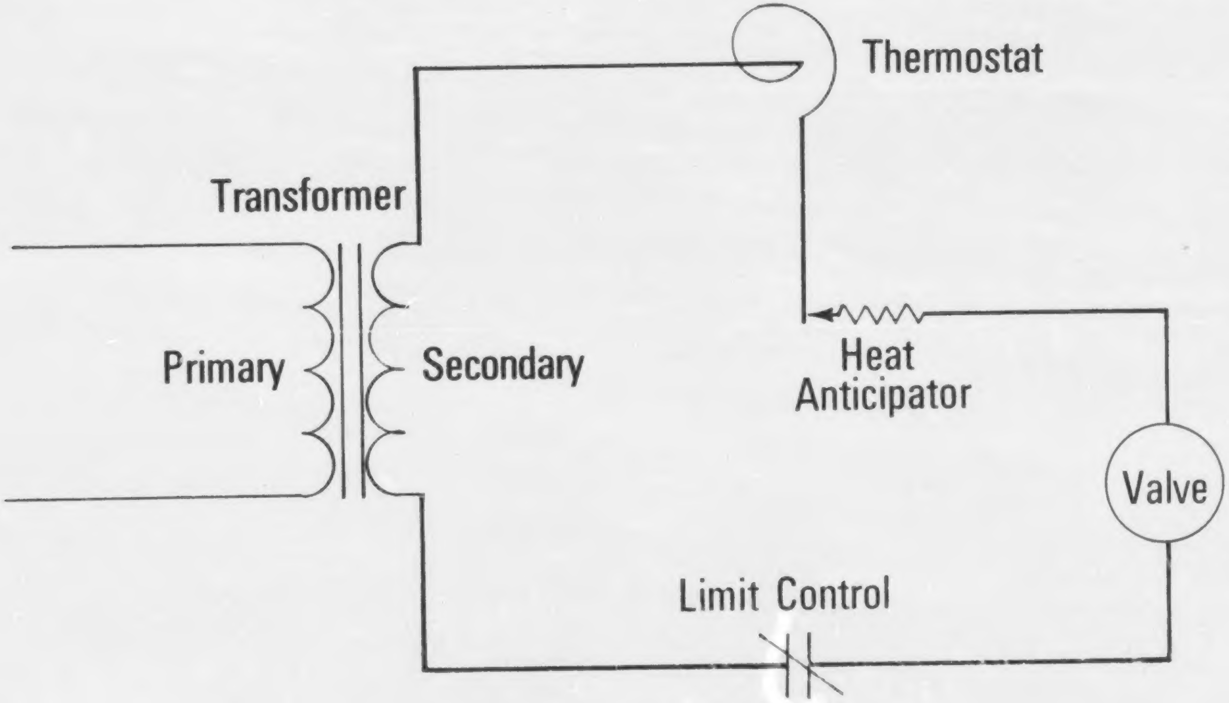


Single-Phase
Motor

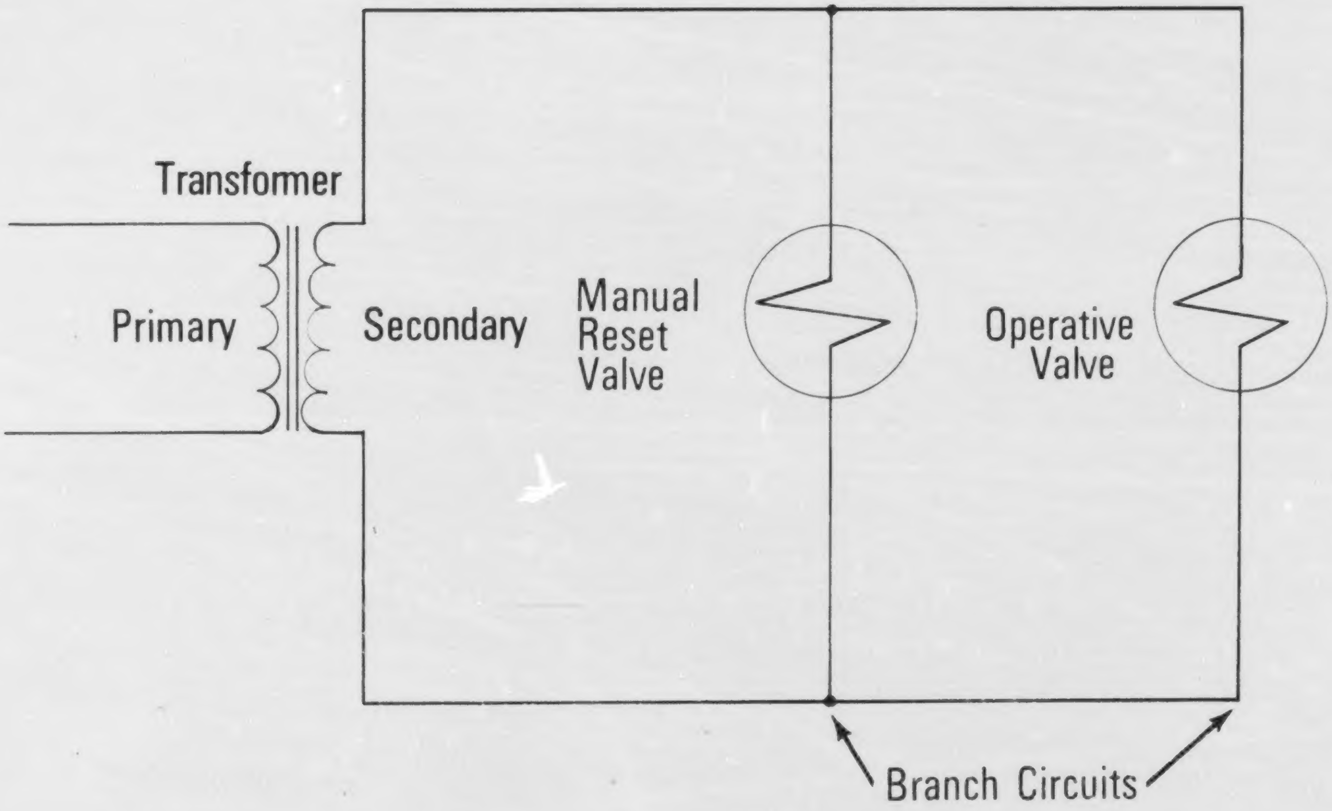


Three –Phase
Compressor Motor

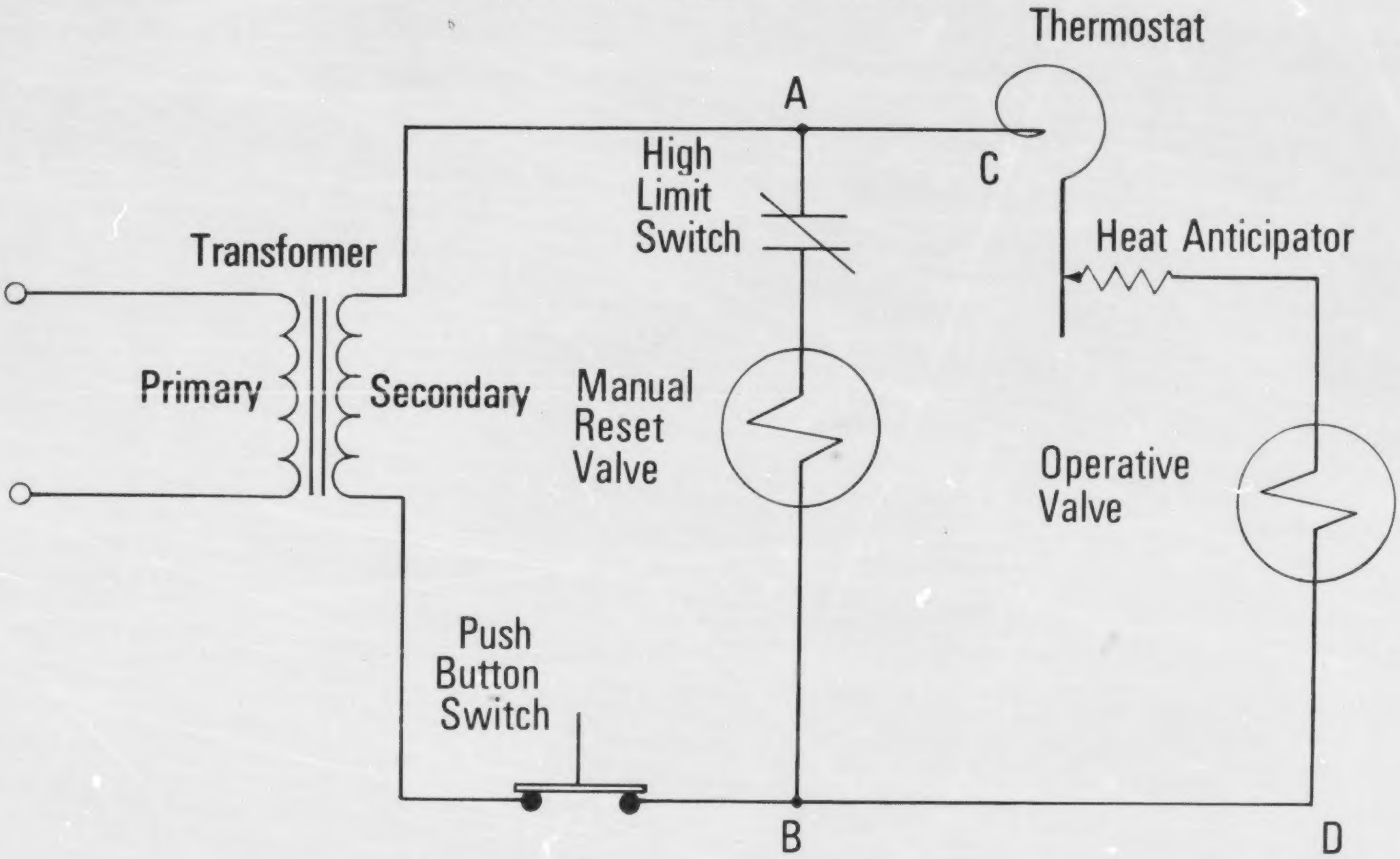
Series Circuit


Thermostat
Transformer
Primary
Secondary
Heat Anticipator
Valve
Limit Control

Parallel Circuit


Transformer
Primary
Secondary
Manual Reset Valve
Operative Valve
Branch Circuits

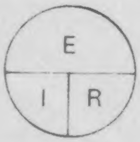
Series-Parallel Circuit


Thermostat
A
C
High Limit Switch
Heat Anticipator
Transformer
Primary
Secondary
Manual Reset Valve
Operative Valve
Push Button Switch
B
D

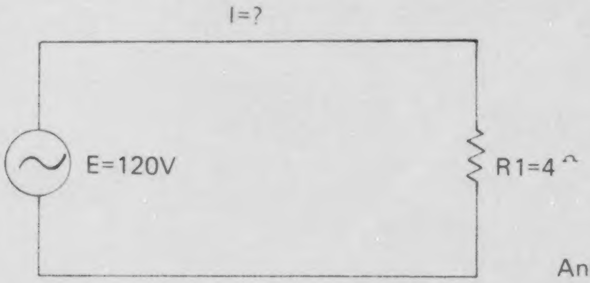
FUNDAMENTALS OF ELECTRICITY
UNIT I

ASSIGNMENT SHEET #1--USE OHM'S LAW

Use ohm's law to solve the following problems.

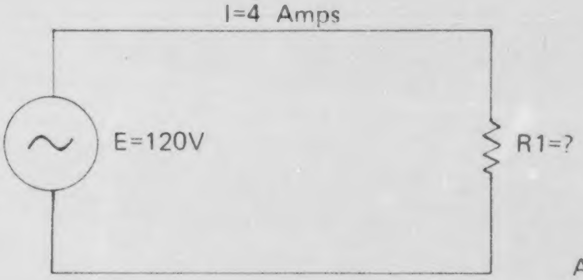


1.


I=?
E=120V
R1=4 Ω

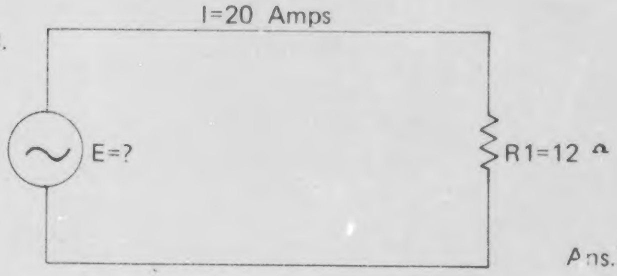
Ans. ____________________

2.


I=4 Amps
E=120V
R1=?

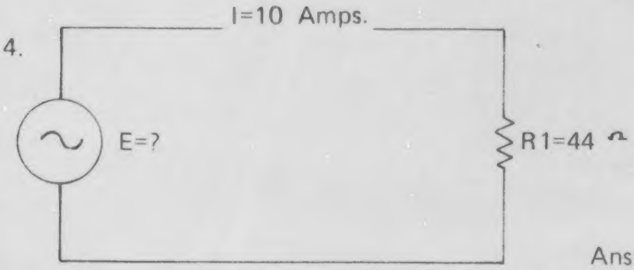
Ans. ____________________

3.


I=20 Amps
E=?
R1=12 Ω

Ans. ____________________

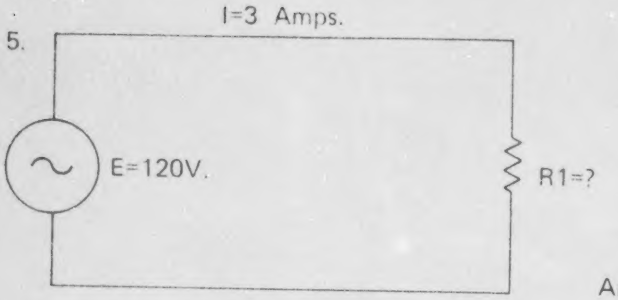
4.


I=10 Amps.
E=?
R1=44 Ω

Ans. ____________________

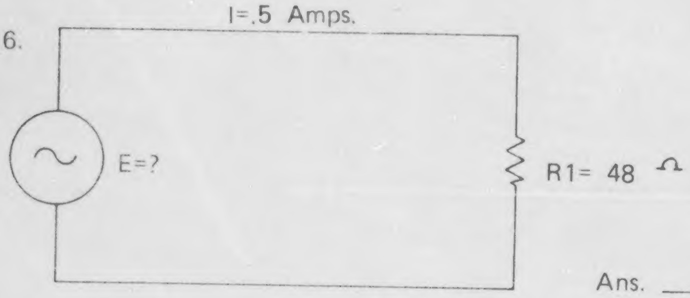
ASSIGNMENT SHEET #1

5.


I=3 Amps.
E=120V.
R1=?

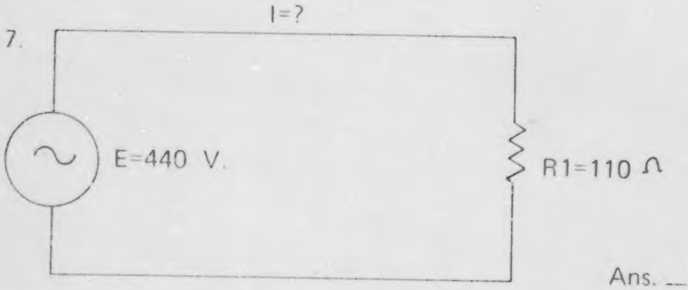
Ans. ______________________

6.


I=.5 Amps.
E=?
R1= 48 Ω

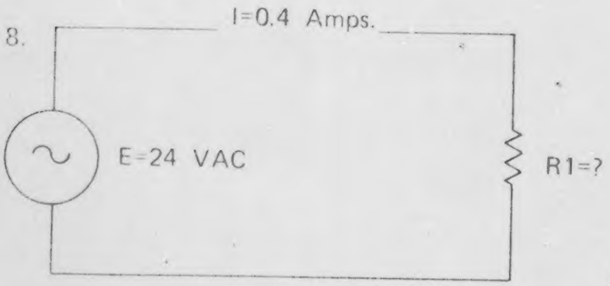
Ans. ______________________

7.


I=?
E=440 V.
R1=110 Ω

Ans. ______________________

8.


I=0.4 Amps.
E=24 VAC
R1=?

Ans. ______________________

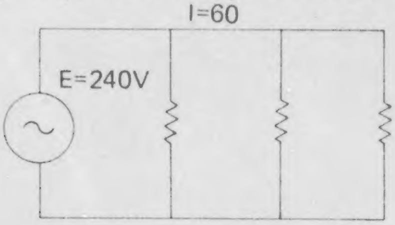
FUNDAMENTALS OF ELECTRICITY
UNIT I

ASSIGNMENT SHEET #2--COMPUTE WATTAGE

Use the equations below to solve the following problems.

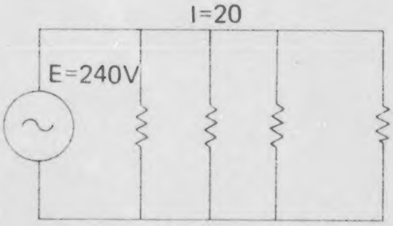
$P = E \times I$, $P = I^2 \times R$, $P = E^2/R$

1.



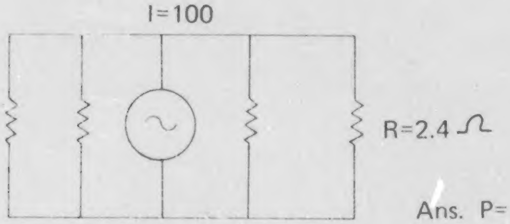
Ans. P= ____________

2.



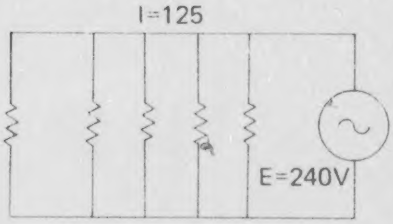
Ans. P= ____________

3.



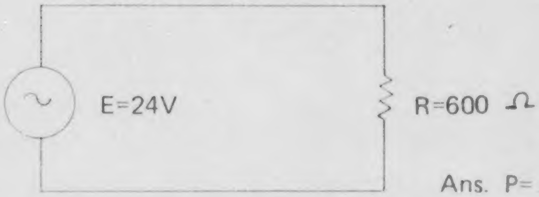
Ans. P= ____________

4.



Ans. P= ____________

5.



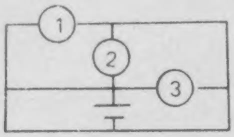
Ans. P= ____________

FUNDAMENTALS OF ELECTRICITY
UNIT I

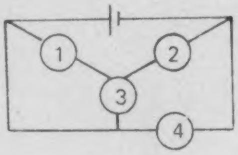
ASSIGNMENT SHEET #3--SELECT THE PARALLEL LOADS

Directions: Select the loads in the following circuits which are wired parallel to the voltage source, and which are not in series with another load. Place the appropriate load designating numbers in the space provided for each circuit at the bottom of the page.

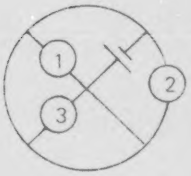
(A)



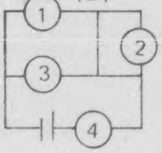
(B)



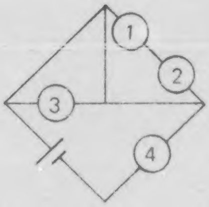
(C)



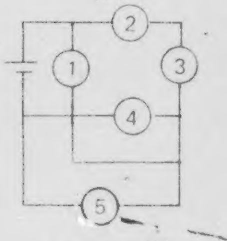
(D)



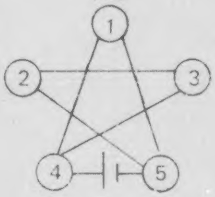
(E)



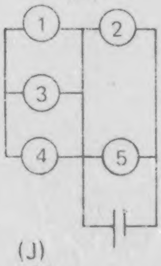
(F)



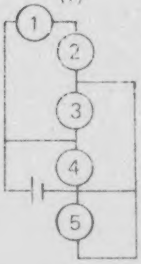
(G)



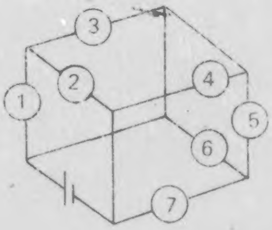
(H)



(I)



(J)



(A) ______ (B) ______ (C) ______ (D) ______ (E) ______

(F) ______ (G) ______ (H) ______ (I) ______ (J) ______

FUNDAMENTALS OF ELECTRICITY
UNIT I

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

1. 30 amps
2. 30 ohms
3. 240 volts
4. 440 volts
5. 40 ohms
6. 24 volts
7. 4 amps
8. 60 ohms

Assignment Sheet #2

1.	14.4 kw	14,400 watts
2.	4.8 kw	4,800 watts
3.	24 kw	24,000 watts
4.	30 kw	30,000 watts
5.		.96 watts

Assignment Sheet #3

a 2

b. 4

c. 3

d. 4

e. 4

f. 1

g. 4

h. 2

i. 3

j. 4

FUNDAMENTALS OF ELECTRICITY
UNIT I

JOB SHEET #1--SOLDER ELECTRICAL WIRE

I. Tools and materials

   A. Soldering gun

   B. Diagonal cutters

   C. Long nose pliers

   D. Wire strippers

   E. Safety glasses

   F. Rosin core solder

   G. Two 6-inch pieces stranded copper wire

   H. Wire terminal

II. Procedure

   A. Put on safety glasses

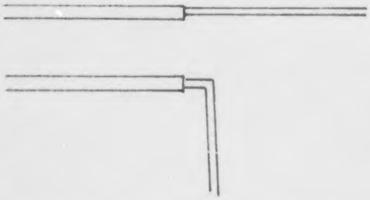
   B. Strip one inch of insulation from the end of each wire

JOB SHEET #1

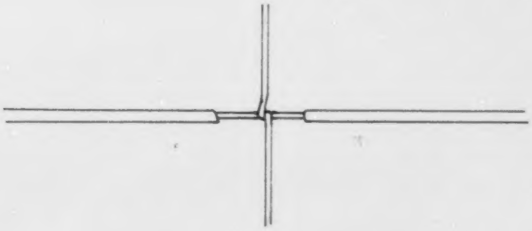
C. Twist the wire until it forms a solid wire (Figure 1)

STRAIGHT SPLICE

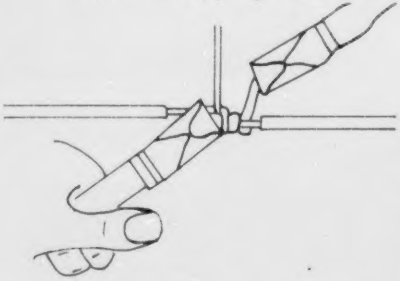
1) Bend 90° Angles in Both Conductors



2) Hook Conductors Together



3) Hold One Conductor Secure While Wrapping the Other



4) Finished Straight Splice

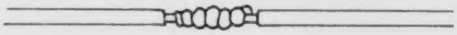


FIGURE 1

D. Clean tip of soldering gun

E. Place the splice on the work bench

(NOTE: The splice should not touch the bench.)

F. Heat soldering gun tip

G. Apply a small amount of solder to the tip

H. Hold the soldering gun on the splice

JOB SHEET #1

I. Apply solder to the splice (Figure 2)

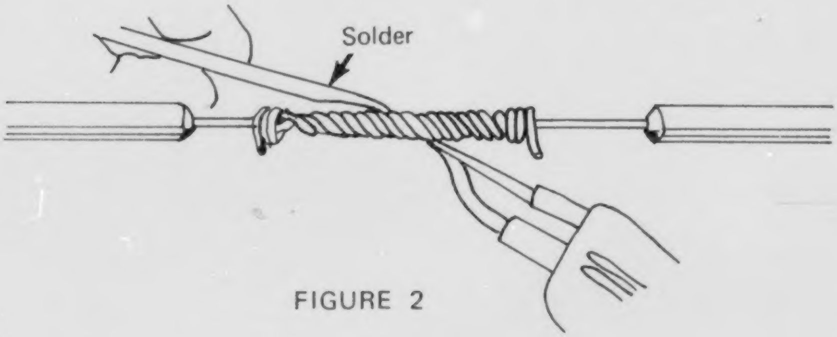


FIGURE 2

J. Remove the solder when the splice fills

K. Strip other end of wire

L. Heat bare wire with soldering gun

M. Apply solder until it fills all strands

(NOTE: This process of applying a coating of solder is referred to as tinning.)

N. Crimp a wire terminal onto the tinned portion of wire

O. Heat the terminal with the soldering gun (Figure 3)

P. Apply solder

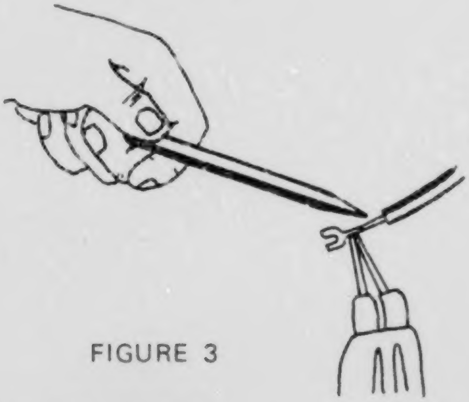


FIGURE 3

Q. Remove gun after solder flows

R. Have the instructor inspect

S. Clean up and put away tools

FUNDAMENTALS OF ELECTRICITY
UNIT I

NAME ______________________________

TEST

1. Match the terms on the right to the correct definitions.

______a. Conductor which has a resistance value in between a good conductor and an insulator

______b. Material with an extremely high resistance to current flow

______c. Ratio of true power to apparent power required

______d. Negatively charged particles

______e. One complete reversal of an alternating current from positive to negative and back to the starting point in one second

______f. Unit of power measurement

______g. Voltage induced in a conductor which is moving through a magnetic field in opposition to the source voltage

______h. Electrical circuit containing semiconductors

______i. Potential difference which causes current to flow

______j. Property in an electrical circuit which opposes any change in the existing current

______k. Flow of electrons through a conductor measured in amperes

______l. Any material with the ability to permit passage of electrical current

1. Resistance
2. Electrons
3. Impedance
4. Semiconductor
5. Watt
6. Solid state
7. Hertz (cycle)
8. Insulator
9. Counter EMF
10. Inductance
11. Voltage (EMF)
12. Capacitance
13. Conductor
14. Power factor
15. Current
16. Parallel circuit
17. Series circuit
18. Series-parallel circuit
19. Branch
20. Low line voltage
21. Load

______m. Factor in an electrical circuit that allows for the storage of electrical charges and opposes any change in existing voltage

______n. Opposition to current flow measured in ohms

______o. Total opposition in an electrical circuit to the flow of alternating current

______p. That portion of a total circuit which is independent of other portions with each receiving full supply voltage

______q. Current has only one path it can take

______r. Power consuming device

______s. Electrical circuit consisting of both series and parallel components

______t. Decrease in voltage available to a power consuming device

______u. Current has more than one path it can take

2. Distinguish between direct and alternating current by placing "AC" in front of the items that refer to alternating current and "DC" in front of the items that refer to direct current.

______a. Flows in one direction then reverses and flows in the opposite direction

______b. Dry cell battery

______c. Supplied by an alternating current generator (alternator)

______d. Flows in one direction only

______e. Supplied by a generator

3. List ten materials which are good conductors of electricity.

a.

b.

c.

d.

e.

f.

g.

h.

i.

j.

4. List five materials which are good insulators of electricity.

   a.

   b.

   c.

   d.

   e.

5. List the equation symbols and equations for ohm's law.

   a. Equation symbols

      1)

      2)

      3)

   b. Equations

      1)

      2)

      3)

6. List three equations for obtaining wattage.

   a.

   b.

   c.

7. List four common conversions of wattage.

   a.

   b.

c.

d.

8. List the three items that make a complete electrical circuit.

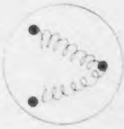
a.

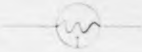
b.

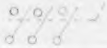
c.

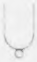
9. Match terms to the correct basic electrical symbols.

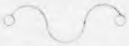
______a. Single pole single throw (SPST)
______b. Ground connection
______c. Capacitor
______d. Push button (normally open)
______e. Switches disconnect
______f. Permanent split capacitor motor
______g. Light
______h. Contacts
______i. Coils
______j. Bimetal switch
______k. Temperature switch
______l. Double pole double throw (DPDT)
______m. Push button (normally closed)
______n. Thermal overload
______o. Fusible link
______p. Resistor or resistance heater
______q. Single-phase motor
______r. Single pole double throw (SPDT)
______s. Thermocouple
______t. Thermistor
______u. Three-phase motor
______v. Connectors

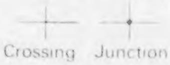
1. 

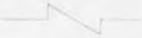
2. 

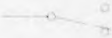
3. 

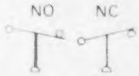
4. 

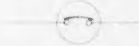
5. 

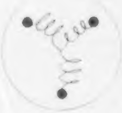
6. 

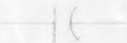
7. 

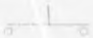
8. 

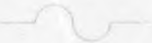
9. 

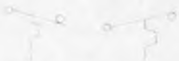
10. 

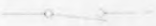
11. 

12. 

13. 

14. 

15. 

16. 

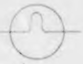
______w. Pressure switches

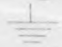
______x. Transformer

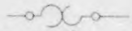
______y. Multiple conductor cable

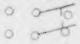
______z. Conductors

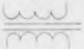
_____aa. Fuse

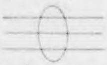
17. 

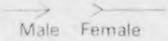
18. 

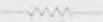
19. 

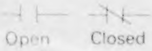
20. 

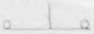
21. 

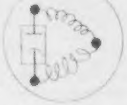
22. 

23. 
Male
Female

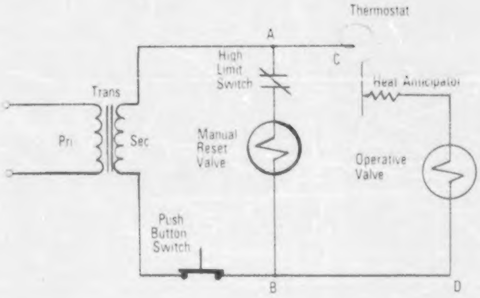
24. 

25. 
Open
Closed

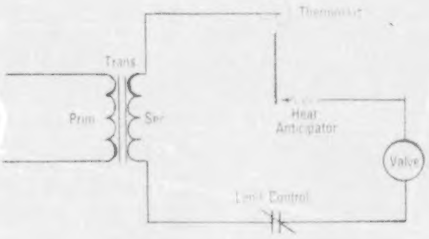
26. 

27. 

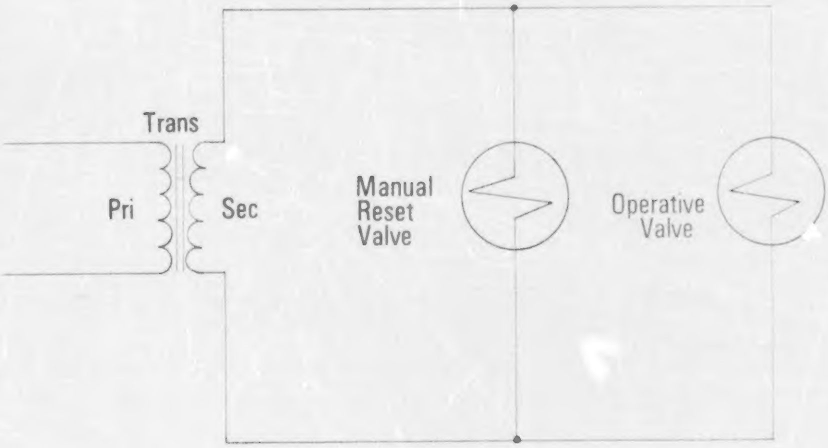
10. Distinguish between a series, parallel and series-parallel circuit by placing an "s" under the picture of a series circuit, a "p" under the picture of a parallel circuit, and an "s-p" under the picture of a series-parallel circuit.


Thermostat
A
C
High Limit Switch
Heat Anticipator
Trans
Pri
Sec
Manual Reset Valve
Operative Valve
Push Button Switch
B
D

a. __________


Thermostat
Trans
Prim
Sec
Heat Anticipator
Valve
Limit Control

b. __________


Trans
Pri
Sec
Manual Reset Valve
Operative Valve

c. __________

11. State four rules for series circuits.

a.

b.

c.

d.

12. State three rules for a parallel circuit.

a.

b.

c.

13. Match the amperage loads on the right to the correct wire sizes.

Wire Size		Amperage loads
______a. 8	1.	40
______b. 14	2.	15
______c. 6	3.	70
______d. 4	4.	55
______e. 12	5.	30
______f. 10	6.	20

14. List three items of concern when working with solid state controls.

a.

b.

c.

15. Demonstrate the ability to:

    a. Use ohm's law

    b. Compute wattage.

    c. Select the parallel loads.

    d. Solder electrical wire.

    (NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

FUNDAMENTALS OF ELECTRICITY
UNIT I

ANSWERS TO TEST

1. a. 4
   b. 8
   c. 14
   d. 2
   e. 7
   f. 5
   g. 9
   h. 6
   i. 11
   j. 10
   k. 15
   l. 13
   m. 12
   n. 1
   o. 3
   p. 19
   q. 17
   r. 21
   s. 18
   t. 20
   u. 16

2. a. AC
   b. DC
   c. AC
   d. DC
   e. DC

3. Any ten of the following:
   a. Silver
   b. Copper
   c. Gold
   d. Aluminum
   e. Tungsten
   f. Zinc
   g. Brass
   h. Platinum
   i. Iron
   j. Nickel
   k. Tin
   l. Steel
   m. Lead
   n. Mercury
   o. Nichrome
   p. Air
   q. Water

4. Any five of the following:
   a. Glass
   b. Rubber
   c. Plastic
   d. Wood
   e. Ceramic
   f. Mica

5. a. Equation symbols
    1) E = Potential measured in volts
    2) I = Current flow measured in amperes
    3) R = Resistance measured in ohms
   b. Equations
    1) $E = I \times R$
    2) $I = E/R$
    3) $R = E/I$

6. a. $P = E \times I$
   b. $P = I^2 \times R$
   c. $P = E^2/R$

7. a. 1,000 watts = 1 kilowatt (kw)
   b. 1,000,000 watts = 1 megawatt
   c. 746 watts = 1 horsepower (hp)
   d. 1 watt-hour = 3.413 b.t.u.'s

8. a. Power source
   b. Connecting wiring
   c. Load

9. a. 16
   b. 18
   c. 12
   d. 13
   e. 3
   f. 27
   g. 17
   h. 25
   i. 7
   j. 10
   k. 15
   l. 20
   m. 26
   n. 19
   o. 5
   p. 24
   q. 1
   r. 8
   s. 4
   t. 2
   u. 11
   v. 23
   w. 9
   x. 21
   y. 22
   z. 6
   aa. 14

10. a. s-p b. s c. p

11. a. The current is the same throughout the circuit

    b. The sum of the voltage drops around a series circuit will equal the supply voltage

    c. The largest voltage drop occurs in the component with the highest resistance

    d. The sum of the resistances of the components equals the total resistance

12. a. Total current equals the sum of the current in all branches

    b. Voltage is the same across all branches

    c. Total resistance is always less than the smallest branch resistance

13. a. 1   d. 3

    b. 2   e. 6

    c. 4   f. 5

14. Any three of the following:

    a. Run electronic signal wiring in shielded cable or metallic conduit to avoid electrically noisy locations

    b. Voltage surge

    c. Replaceable modules for field repair

    d. Exposure to excessively high temperature will damage solid state devices

15. Performance skills evaluated to the satisfaction of the instructor

ELECTRICAL TEST INSTRUMENTS
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to match terms associated with electrical test instruments to the correct definitions, and list safety rules pertaining to electrical test instruments. The student should be able to read and use a voltmeter, ammeter, ohmmeter, wattmeter, and use a hermetic analyzer and capacitor analyzer. The student should also be able to test a capacitor with an ohmmeter. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with electrical test instruments to the correct definitions.
2. List ten safety rules pertaining to electrical test instruments.
3. List general rules for the protection of electrical test instruments.
4. Identify electrical test instruments.
5. Match the meter to its application.
6. List two steps for reading a meter scale.
7. Discuss three circuit conditions.
8. Describe the procedure for zeroing the ohmmeter.
9. Demonstrate the ability to:
    a. Read a voltmeter scale.
    b. Read an ammeter scale.
    c. Read an ohmmeter scale.
    d. Determine start, run, and common of a single-phase motor.
    e. Use a voltmeter.
    f. Use an ohmmeter.

g. Use a wattmeter.

h. Use an ammeter.

i. Use a hermetic analyzer.

j. Use a capacitor analyzer.

k. Test a capacitor with an ohmmeter.

ELECTRICAL TEST INSTRUMENTS
UNIT II

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information, assignment, and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information and assignment sheets.

   F. Demonstrate and discuss the procedures outlined in the job sheets.

   G. Demonstrate the use and care of electrical test instruments.

   H. Obtain films from meter manufacturers.

   I. Construct test boards.

   J. Give each student a copy of the manufacturer's instructions for each electrical test instrument in the shop.

   K. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Complete assignment and job sheets.

   D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM 1--Electrical Test Instruments

      2. TM 2--Electrical Test Instruments (Continued)

D. Assignment sheets

  1. Assignment Sheet #1--Read a Voltmeter Scale
  2. Assignment Sheet #2--Read an Ammeter Scale
  3. Assignment Sheet #3--Read an Ohmmeter Scale
  4. Assignment Sheet #4--Determine Start, Run, and Common of a Single-Phase Motor

E. Answers to assignment sheets

F. Job sheets

  1. Job Sheet #1--Use a Voltmeter
  2. Job Sheet #2--Use an Ohmmeter
  3. Job Sheet #3--Use a Wattmeter
  4. Job Sheet #4--Use an Ammeter
  5. Job Sheet #5--Use a Hermetic Analyzer
  6. Job Sheet #6--Use a Capacitor Analyzer
  7. Job Sheet #7--Test a Capacitor With an Ohmmeter

G. Test

H. Answers to test

II. References:

A. Woodroof, William Walton. *Servicing Comfort Cooling Systems.* NHAW Home Study Institute, Columbus, Ohio, 1974.

B. *Basic Electricity for Appliances.* Indianapolis, Indiana: Howard W. Sams and Co., 1975.

ELECTRICAL TEST INSTRUMENTS
UNIT II

INFORMATION SHEET

I. Terms and definitions

A. Zero--To align meter needle over zero on the ohm scale

B. Range--Limits of a particular portion of a meter

Example: 250 VAC (volts alternating current)--This range would be all right to use for any AC voltage 1 VAC to 250 VAC; anything over that would damage the meter

C. Calibrate--To adjust a meter so that the needle is properly aligned to the proper set point on the scale

D. Continuity--Complete circuit in which current can flow

E. Line voltage--Main power supply

F. Probes--Insulated ends on a test instrument's leads that are held while checking a circuit

G. Locked rotor amperage (L.R.A.)--Amperage a motor would draw when the rotor is not turning with power applied

H. Full load amperage (F.L.A.)--Total current a device draws when it is running fully loaded

I. Infinity (infinite resistance)--Extreme end of the ohm scale; designated by ∞

J. Bleed resistor--Resistor connected between capacitor terminals to minimize arcing of the relay points; 20,000 ohm 2 watt carbon resistor

II. Safety rules pertaining to electrical test instruments

A. Stand on dry, nonconductive surfaces when testing live circuits

B. Be sure the power is off when checking a circuit with an ohmmeter

(NOTE: An ohmmeter could explode if it came into contact with line voltage.)

C. Do not use meter leads with defective probes

INFORMATION SHEET

- D. Do not have both hands in a high voltage cabinet

  (NOTE: Clip one voltmeter lead on and then take the other lead and check the circuit.)
- E. Do not touch metal cabinet or other grounded material
- F. Wear eye protection
- G. Use fuse pullers
- H. Do not work on live voltage circuits by yourself
- I. Do not assume that the power is off
- J. Discharge capacitors with a bleed resistor before removing or testing

III. General rules for the protection of electrical test instruments

- A. Keep stored in proper cases
- B. Avoid bumping or jolting
- C. Use only for intended purpose
- D. Use within meter range limits
- E. Avoid exposure to extreme temperatures
- F. Keep clean
- G. Keep dry
- H. Set meter in highest range prior to taking reading

IV. Electrical test instruments (Transparencies 1 and 2)

- A. Voltmeter
- B. Ohmmeter
- C. Multimeter
- D. Wattmeter
- E. Ammeter

INFORMATION SHEET

F. Hermetic analyzer

G. Capacitor analyzer

V. Meter application

A. Voltmeter

1. Measures line voltage
2. Measures voltage drop at the load
3. Measures low voltage
4. Indicates open components

(NOTE: A switch or other nonload circuit component will give a voltage reading across it if it is open.)

B. Ohmmeter

(CAUTION: Be sure all power is off before checking an electrical circuit with an ohmmeter.)

1. Checks for a path for current flow (continuity)
2. Checks for resistance to current flow
3. Determines motor windings
4. Checks for shorts and grounds
5. Checks capacitors

(CAUTION: Be sure that the charge is bled off of a capacitor with a bleed resistor before checking it with an ohmmeter.)

C. Multimeter

1. AC voltmeter
2. DC voltmeter
3. Ohmmeter
4. Milliammeter

INFORMATION SHEET

D. Wattmeter

1. Indicates line voltage
2. Indicates starting watts
3. Indicates running watts

E. Ammeter

1. Checks starting amperage
2. Checks running amperage
3. Checks locked rotor amperage

F. Hermetic analyzer

1. Checks compressor for grounds
2. Checks compressor for open windings
3. May be used to start a locked rotor compressor
4. Starts and runs a compressor

G. Capacitor analyzer

1. Measures capacitance value
2. Measures power factor
3. Indicates open capacitors
4. Indicates shorted capacitors
5. Indicates leaky capacitors

VI. Steps for reading a meter scale

A. Read meter in the center two-thirds of the scale for greater accuracy

B. Count the number of graduations between the major divisions

VII Circuit conditions

A. Open circuit

1. Most frequent circuit problem

INFORMATION SHEET

2. No path for current flow
3. Caused by
    - a. Pitted contacts
    - b. Defective relay coil
    - c. Broken wire
    - d. Blown fuse
    - e. Tripped circuit breaker
    - f. Open switch
4. Voltmeter will indicate voltage across an open

B. Short circuit

1. Second most frequent circuit problem
2. Electrical circuit that has a lower resistance than intended
3. Indications
    - a. Blown fuses
    - b. Tripped circuit breakers
    - c. Melted wires
    - d. Swollen run capacitor cans
    - e. Blackened terminals
    - f. Burnt case

Example: Touching a screwdriver to a current carrying conductor and at the same time against the side of the appliance cabinet would result in a blown fuse, a badly burnt screwdriver, a burnt spot on the cabinet, and possible personal injury

C. Grounded circuit

1. A high resistance path that current may take to a common ground

INFORMATION SHEET

2. May not cause a blown fuse or tripped circuit breaker

3. May be determined with an ohmmeter (Figure 1)

   (CAUTION: There must not be any voltage applied to the circuit when checking with an ohmmeter

   a. Check from lead or terminal to a common ground

   b. Meter will indicate a medium to high resistance reading

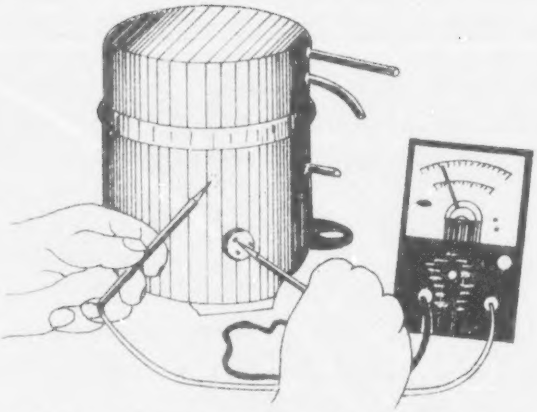


FIGURE 1

(NOTE: If touching one lead to the dome, remove the paint first or touch the lead to a refrigerant line.)

VIII. Zeroing the ohmmeter

A. Select range

B. Hold leads together

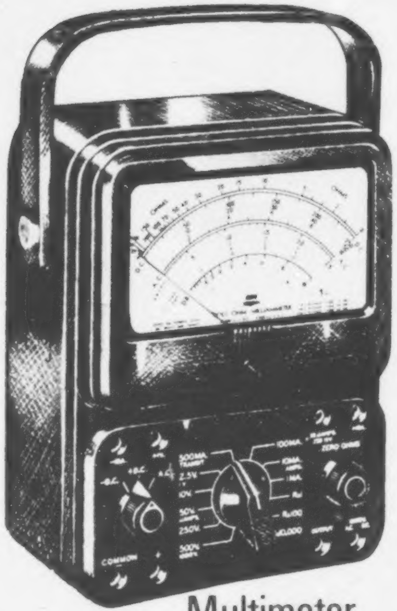
C. Check to see that the needle moves to the extreme right

D. Align the needle directly over "O" on the ohm scale

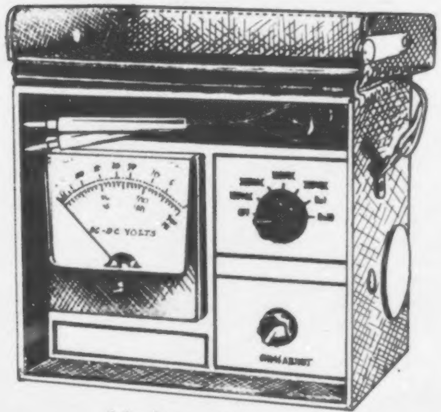
   (NOTE: If the meter cannot be zeroed the meter's batteries will have to be changed.)

E. Zero ohmmeter each time before using or when changing ranges

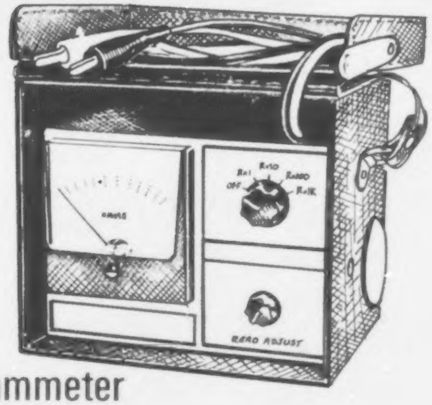
Electrical Test Instruments


COMMON
500MA
2.5V
10V
50V
250V
500V
100MA
10MA
1MA
ZERO OHMS

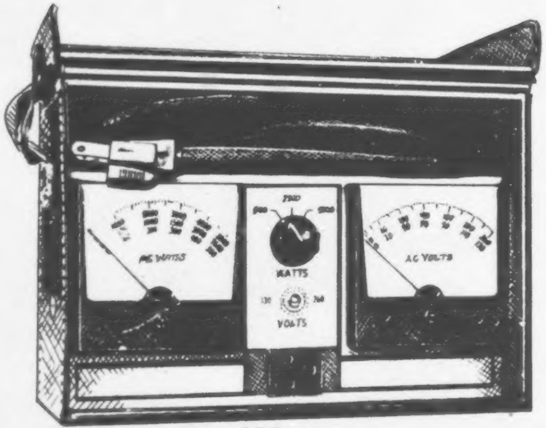
Multimeter


AC-DC VOLTS
OHM ADJUST

Voltmeter


OHMS
R×1
R×10
R×100
R×1K
OFF
ZERO ADJUST

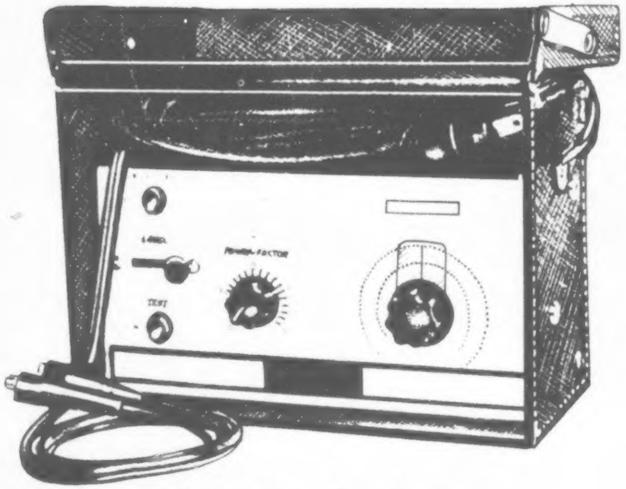
Ohmmeter


AC WATTS
WATTS
VOLTS
AC VOLTS

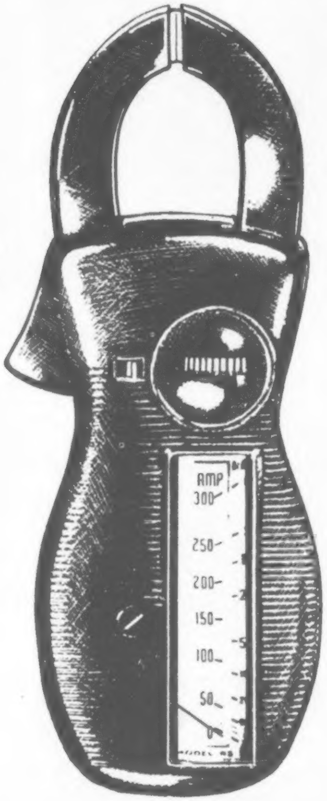
Wattmeter

Electrical Test Instruments

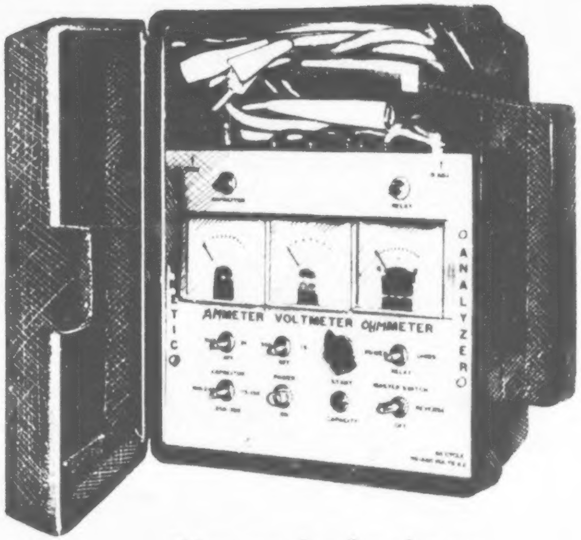
(Continued)


POWER-FACTOR
TEST

Capacitor Analyzer


AMP
300
250
200
150
100
50
0

Ammeter


AMMETER VOLTMETER OHMMETER
ANALYZER

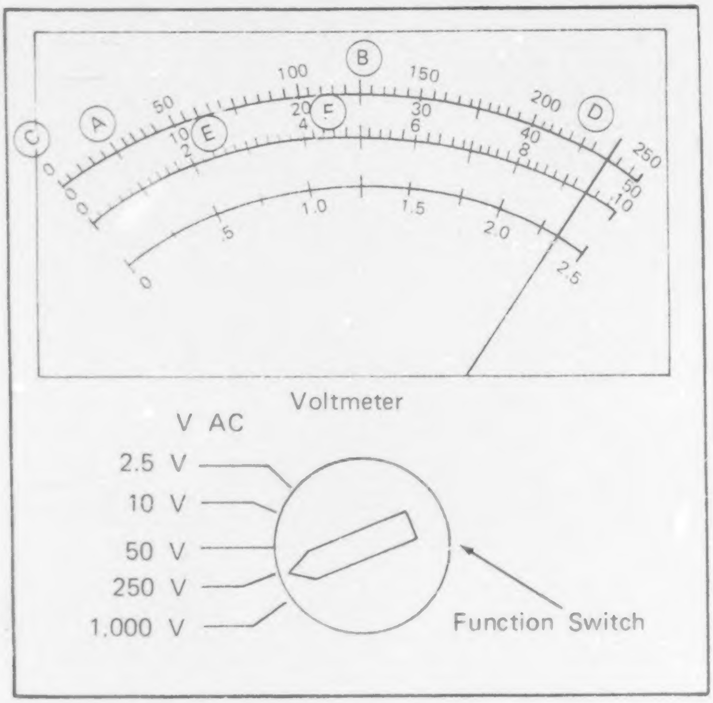
Hermetic Analyzer

ELECTRICAL TEST INSTRUMENTS
UNIT II

ASSIGNMENT SHEET #1--READ A VOLTMETER SCALE

Read the voltages on the meter in Figure 1. This voltmeter will read from left to right on the scale. The scale to use is determined by the position of the function switch.

FIGURE 1



C
A
B
D
E
F
0
0
0
50
100
150
200
250
10
20
30
40
50
2
4
6
8
10
0
.5
1.0
1.5
2.0
2.5
Voltmeter
V AC
2.5 V
10 V
50 V
250 V
1,000 V
Function Switch

Example: With the function switch at 250v, the needle on the meter is indicating 235v

1. Function switch in the 250v position. Needle is pointing to "B" on the scale.

2. Function switch in the 50v position. Needle is pointing to "B" on the scale.

3. Function switch in the 1000v position.

   (NOTE: Use the 0-10 scale when in the 1000v position.)

   Needle is pointing to "E" on the scale.

ASSIGNMENT SHEET #1

4. Function switch in the 250v position. Needle is pointing to "A" on the scale.

5. Function switch in the 250v position. Needle is pointing to "C" on the scale.

6. Function switch in the 1000v position. Needle is pointing to "F" on the scale.

7. Function switch in the 50v position. Needle is pointing to "F" on the scale.

8. Function switch in the 250v position. Needle is pointing to "D" on the scale.

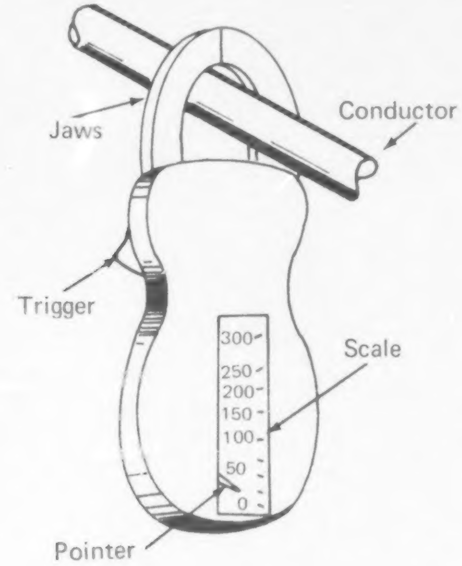
9. Function switch in the 250v position. Needle is pointing to "F" on the scale.

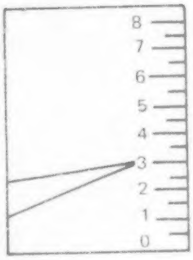
10. Function switch in the 50v position. Needle is pointing to "D" on the scale.

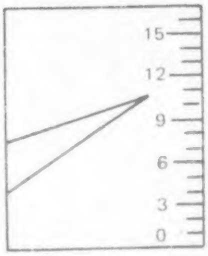
ELECTRICAL TEST INSTRUMENTS
UNIT II

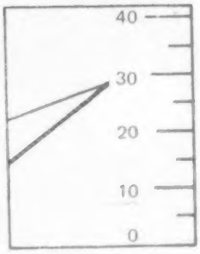
ASSIGNMENT SHEET #2--READ AN AMMETER SCALE

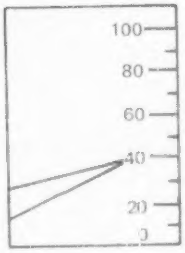
Read the amperages on the scales below. The ammeter shown has a rotary scale with five amperage scales on it.

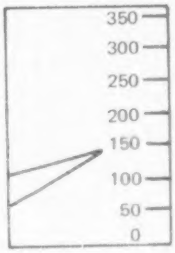

Jaws
Conductor
Trigger
Scale
300
250
200
150
100
50
0
Pointer








100
80
60
40
20
0


350
300
250
200
150
100
50
0

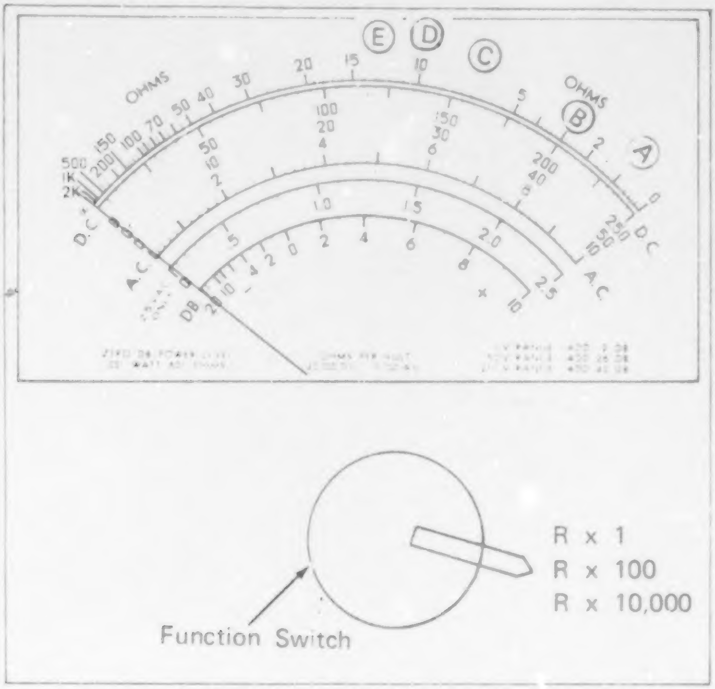
1. ____________ 2. ____________ 3. ____________ 4. ____________ 5. ____________

(NOTE: Always set the ammeter on its highest scale and then come down to a lower scale for a more accurate reading.)

ELECTRICAL TEST INSTRUMENTS
UNIT II

ASSIGNMENT SHEET #3--READ AN OHMMETER SCALE

Read the resistances on the ohmmeter scale below. This ohmmeter scale reads from right to left.



(NOTE: The letters on the scale are there for the purpose of working this exercise and they do not appear on actual ohmmeters.)

Example: With the function switch at R x 10,000 and the needle pointing at 2 on the scale

$$\begin{array}{r} 10{,}000 \\ \times\ 2 \\ \hline \text{ans. } 20{,}000 \text{ ohms} \end{array}$$

1. Function switch in the R x 1 position. Needle is pointing to "B" on the scale.

   ans. ____________________

2. Function switch in the R x 10,000 position. Needle is pointing to "E" on the scale.

   ans. ____________________

ASSIGNMENT SHEET #3

3. Function switch in the R x 100 position. Needle is pointing to "C" on the scale.

ans. ____________________

4. Function switch in the R x 10,000 position. Needle is pointing to "A" on the scale.

ans. ____________________

5. Function switch in the R x 1 position. Needle is pointing to "E" on the scale.

ans. ____________________

6. Function switch in the R x 100 position. Needle is pointing to "B" on the scale.

ans. ____________________

7. Function switch in the R x 1 position. Needle is pointing to "A" on the scale.

ans. ____________________

8. Function switch in the R x 1 position. Needle is pointing to "D" on the scale.

ans. ____________________

9. Function switch in the R x 100 position. Needle is pointing to "E" on the scale.

ans. ____________________

10. Function switch in the R x 10,000 position. Needle is pointing to "C" on the scale.

ans. ____________________

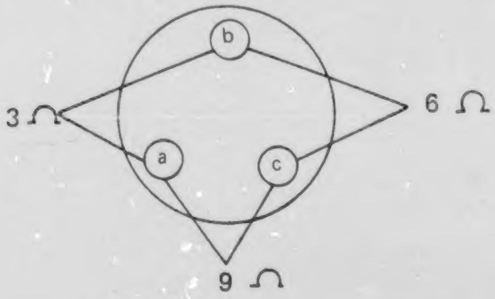
ELECTRICAL TEST INSTRUMENTS
UNIT II

ASSIGNMENT SHEET #4--DETERMINE START, RUN, AND COMMON OF A SINGLE · PHASE MOTOR

Hermetic compressors have three terminals that are connected to the internal motor windings. By taking the three following resistance readings, it can be determined which terminals are start, run, and common.

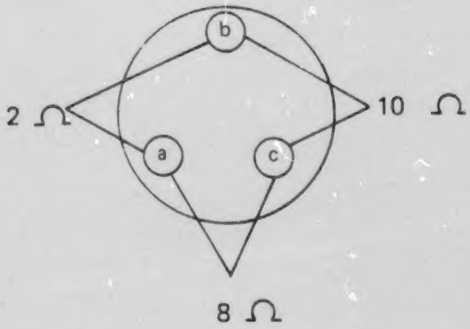
1. Highest reading is start and run terminals.
2. Next to highest is start and common terminals.
3. Lowest is common and run terminals.

Example: Terminal a is run
Terminal b is common
Terminal c is start



Do the following problems:

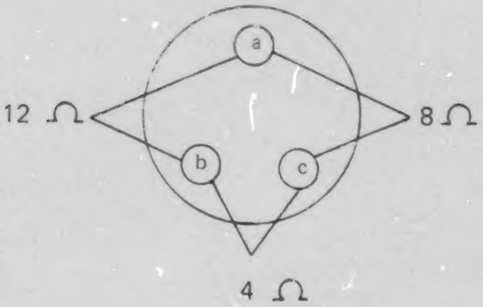
1.



a. ______________ b. ______________ c. ______________

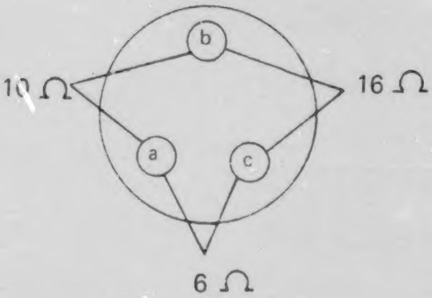
ASSIGNMENT SHEET #4

2.


a
12 Ω
8 Ω
b
c
4 Ω

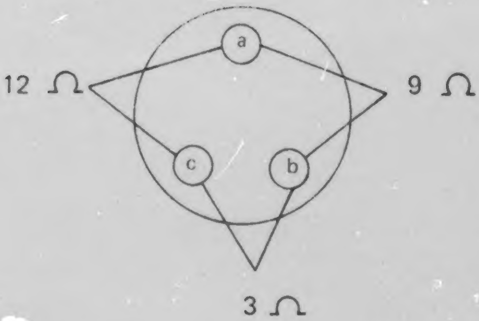
a. ____________ b. ____________ c. ____________

3.


b
10 Ω
16 Ω
a
c
6 Ω

a. ____________ b. ____________ c. ____________

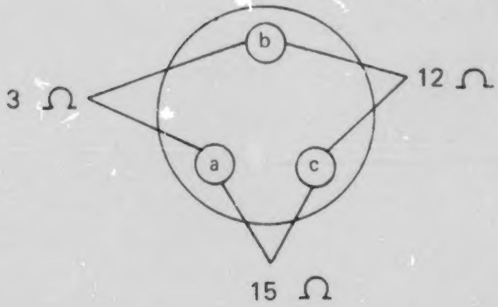
4.


a
12 Ω
9 Ω
c
b
3 Ω

a. ____________ b. ____________ c. ____________

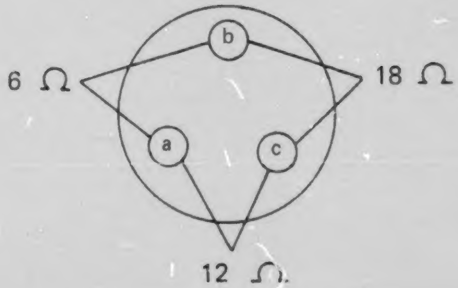
ASSIGNMENT SHEET #4

5.


b
3 Ω
12 Ω
a
c
15 Ω

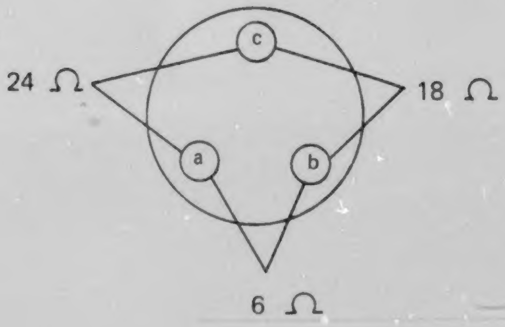
a. ____________ b. ____________ c. ____________

6.


b
6 Ω
18 Ω
a
c
12 Ω

a. ____________ b. ____________ c. ____________

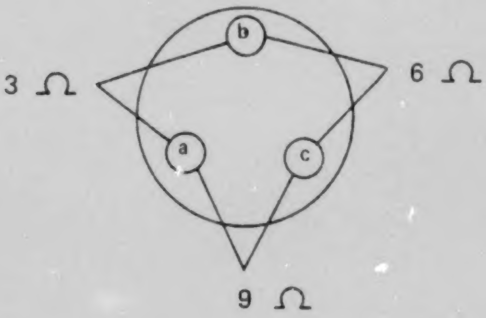
7.


c
24 Ω
18 Ω
a
b
6 Ω

a. ____________ b. ____________ c ____________

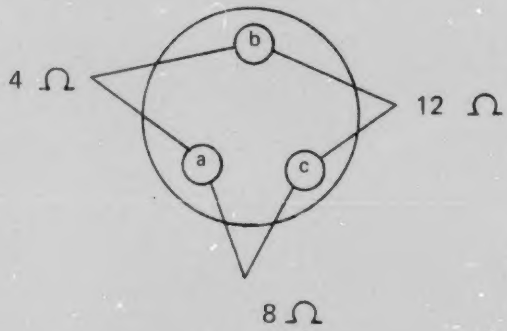
ASSIGNMENT SHEET #4

8.



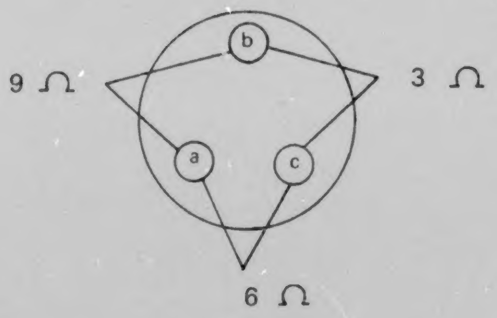
a. ____________ b. ____________ c. ____________

9.


b
4 Ω
12 Ω
a
c
8 Ω

a. ____________ b. ____________ c. ____________

10.



a. ____________ b. ____________ c. ____________

ELECTRICAL TEST INSTRUMENTS
UNIT II

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

1. 125 volts
2. 25 volts
3. 240 volts
4. 25 volts
5. 0 volts
6. 440 volts
7. 22 volts
8. 225 volts
9. 110 volts
10. 45 volts

Assignment Sheet #2

1. 3 amps
2. 11 amps
3. 30 amps
4. 40 amps
5. 150 amps

Assignment Sheet #3

1. 3 ohms
2. 130,000 ohms
3. 700 ohms
4. 10,000 ohms
5. 13 ohms

6. 300 ohms
7. 1 ohm
8. 10 ohms
9. 1,300 ohms
10. 70,000 ohms

Assignment Sheet #4

1. a. Common
   b. Run
   c. Start
2. a. Start
   b. Run
   c. Common
3. a. Common
   b. Start
   c. Run
4. a. Start
   b. Common
   c. Run
5. a. Run
   b. Common
   c. Start
6. a. Common
   b. Run
   c. Start
7. a. Run
   b. Common
   c. Start

8.
   a. Run
   b. Common
   c. Start

9.
   a. Common
   b. Run
   c. Start

10.
   a. Start
   b. Run
   c. Common

ELECTRICAL TEST INSTRUMENTS
UNIT II

JOB SHEET #1--USE A VOLTMETER

I. Tools and materials

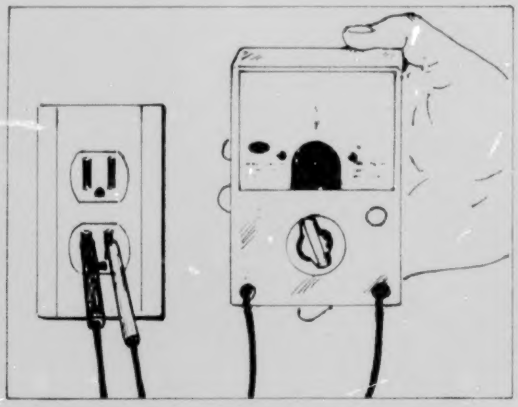
- A. Voltmeter
- B. Safety glasses
- C. 120 VAC wall outlet
- D. 240 VAC wall outlet
- E. 240 VAC 1 phase disconnect
- F. Three phase disconnect

(NOTE: All of these materials should be connected to the proper voltage.)

II. Procedure

- A. Put on safety glasses
- B. Select highest AC scale
- C. Check across a 120 VAC wall outlet (Figure 1)

FIGURE 1

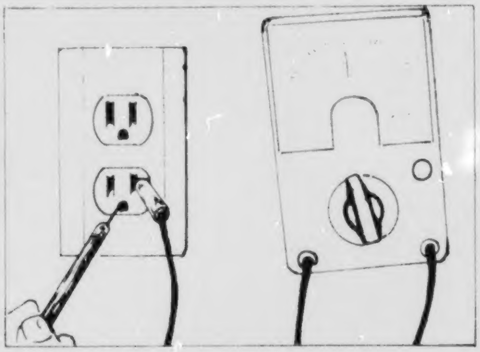


JOB SHEET #1

D. Select meter scale that will allow for the most accurate reading

E. Check from each side to ground (Figure 2)

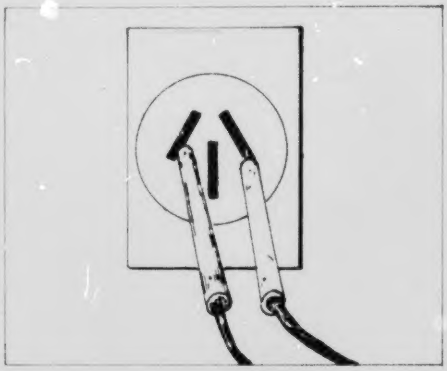
FIGURE 2



F. Switch to highest AC scale

G. Check across a 240 VAC wall outlet (Figure 3)

FIGURE 3

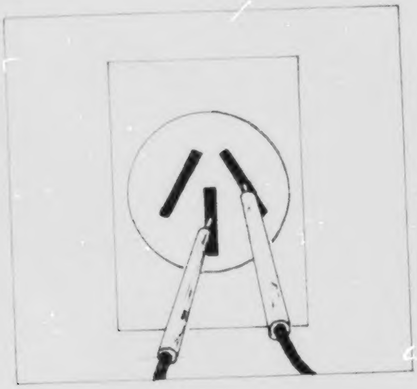


H. Select meter scale that will allow for the most accurate reading

JOB SHEET #1

I. Check from each side to ground (Figure 4)

FIGURE 4



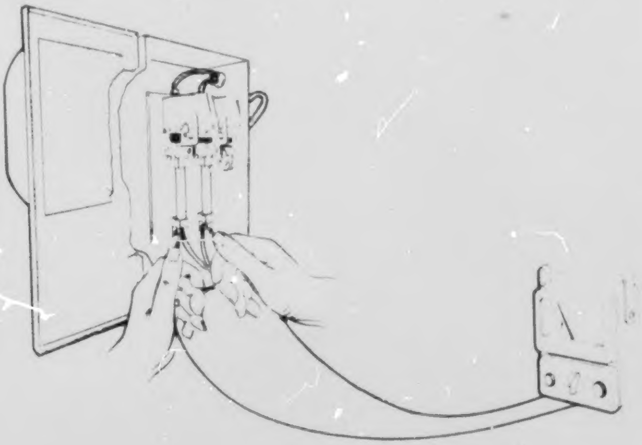
J. Switch to highest AC scale

K. Check line side of disconnect

L. Select meter scale that will allow for the most accurate reading

M. Check load side of disconnect (Figure 5)

FIGURE 5



N. Repeat steps J through M and check a three-phase disconnect

O. Have instructor observe your work

P. Put away voltmeter

ELECTRICAL TEST INSTRUMENTS
UNIT II

JOB SHEET #2--USE AN OHMMETER

I. Tools and materials

  A. Ohmmeter

  B. Safety glasses

  C. Bleed resistor--2 watt 20K ohm

  D. Hermetic compressor, single-phase

  E. Plug type fuse

  F. Cartridge type fuse

II. Procedure

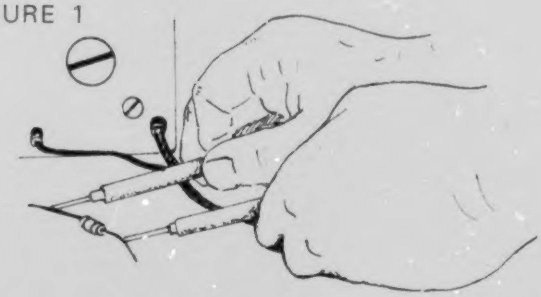
  A. Put on safety glasses

  B. Select highest ohm scale

  C. Zero meter

  D. Touch meter probes to resistor leads (Figure 1)

FIGURE 1



JOB SHEET #2

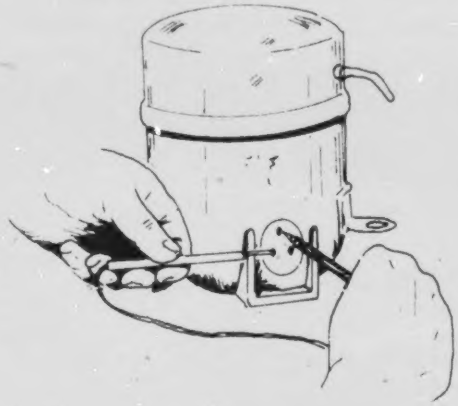
E. Read the resistance on the ohmmeter scale

F. Select R x 1 scale

G. Rezero meter

H. Touch meter leads to two compressor terminals (Figure 2)

FIGURE 2



I. Record resistance reading

J. Move one probe to remaining terminal

K. Record resistance reading

L. Take the third resistance reading

M. Record the third resistance reading

N. Identify the start, run, and common terminals

O. Have the instructor check your work

P. Check a plug type fuse

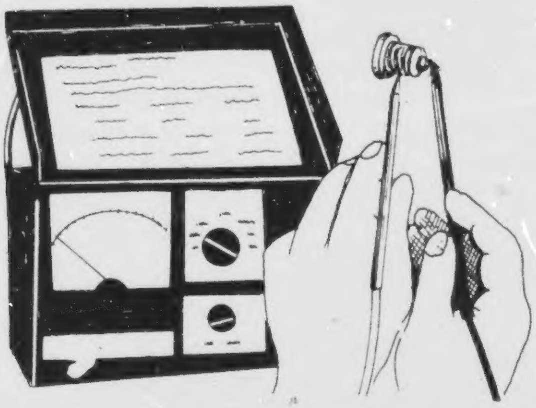
Q. Touch one ohmmeter probe to outer metallic portion

JOB SHEET #2

R. Touch the ohmmeter probe to the button on the bottom (Figure 3)

(NOTE: Never check a fuse with an ohmmeter in a complete circuit.)

FIGURE 3



S. If the needle swings to zero the fuse is good

T. If the needle stays at infinity the fuse is not good

U. Touch the ohmmeter leads to each end of a cartridge type fuse

(NOTE: A good or bad cartridge fuse will be indicated in the same manner as the plug fuse was.)

V. Have instructor check your work.

W. Turn ohmmeter to the "off" position or to the highest AC voltage range

X. Put away tools and materials

ELECTRICAL TEST INSTRUMENTS
UNIT II

JOB SHEET #3--USE A WATTMETER

I. Tools and materials

   A. Wattmeter

   B. Safety glasses

   C. Power consuming device

II. Procedure

   A. Put on safety glasses

   B. Read instructions supplied with wattmeter if available

   C. Select the proper voltage

   D. Connect the wattmeter to line voltage

   E. Select the highest wattage scale

   F. Connect current consuming device to wattmeter

   G. Have instructor check

   H. Start the current consuming device

   I. Record starting wattage

   J. Allow unit to run a few minutes while the wattage levels out

   K. Select wattage scale that will allow for the easiest reading

   L. Record running wattage

   M. Obtain full load amperage from units name plate

   N. Divide the voltage into the wattage to obtain the F.L.A.

   (NOTE: Remember watts law is primarily for DC power, but for our purposes the power factor is generally close enough to one that it can be used for AC power.)

   O. Use an ammeter to check your answer

   (NOTE: The use of the ammeter is covered in Job Sheet #4 of this unit.)

   P. Have instructor check

   Q. Put away meter and materials

ELECTRICAL TEST INSTRUMENTS
UNIT II

JOB SHEET #4--USE AN AMMETER

I. Tools and materials

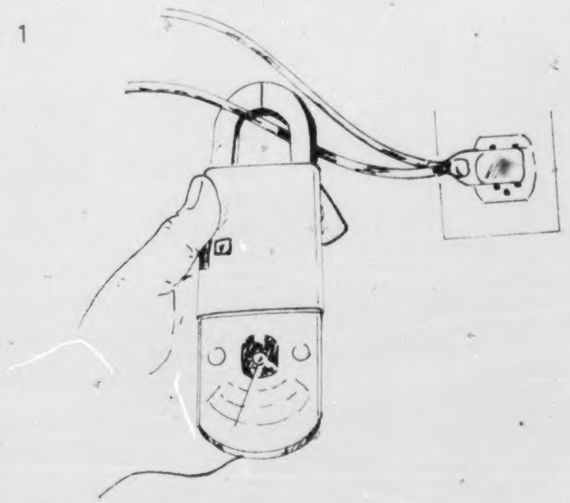
- A. Clamp on ammeter
- B. Safety glasses
- C. Refrigeration system

II. Procedure

- A. Put on safety glasses
- B. Select highest amperage scale
- C. Clamp ammeter around one conductor of the line cord (Figure 1)

(NOTE: Placing the ammeter around two conductors of single-phase power will cancel out the amperage reading.)

FIGURE 1



- D. Start refrigeration system
- E. Record starting amperage

(NOTE: Starting amperage will only last an instant.)

JOB SHEET #4

F. Allow the system to run

G. Record running amperage

H. Check F.L.A. on name plate

I. Compare the name plate amperage to the ammeter reading

J. Have instructor check

K. Put away meter and materials

ELECTRICAL TEST INSTRUMENTS
UNIT II

JOB SHEET #5-USE A HERMETIC ANALYZER

I. Tools and materials

  A. Hermetic analyzer

  B. Safety glasses

  C. Refrigeration system with a hermetic compressor

II. Procedure

  A. Put on safety glasses

  B. Check to be sure power is off

  C. Remove wires from compressor terminals

  D. Determine common, start and run terminals

  E. Read instructions on the use of the hermetic analyzer

  F. Connect analyzer to compressor terminals

  G. Have instructor check

  H. Start and run compressor with analyzer

  (NOTE: Do not run the system for a long length of time without the condenser and evaporator fans running also.)

  I. Check running amperage

  J. Turn system off

  K. Disconnect analyzer from system

  L. Replace wires to compressor terminals

  M. Put away analyzer and refrigeration system

ELECTRICAL TEST INSTRUMENTS
UNIT II

JOB SHEET #6 USE A CAPACITOR ANALYZER

I. Tools and materials

   A. Safety glasses

   B. Capacitor analyzer

   C. Bleed resistor

   D. Run capacitors

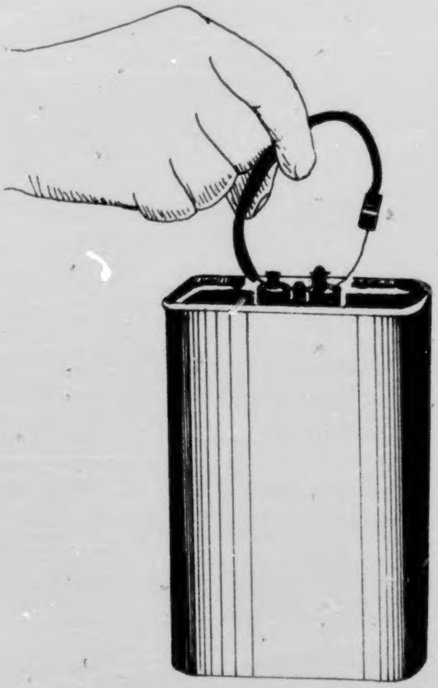
II. Procedure

   A. Put on safety glasses

   B. Discharge capacitor with bleed resistor (Figure 1)

   (NOTE: A bleed resistor should be used to discharge capacitors. Some capacitors are internally fused and shorting them with a screwdriver would ruin them.)

FIGURE 1



JOB SHEET #6

C. Read instructions on the use of the analyzer

(CAUTION: A shield should be placed between the capacitor and the individual doing the testing in case of a possible explosion.)

D. Check capacitor for opens

E. Check capacitor for grounds

F. Check microfarad capacity of capacitor

G. Check several different capacitors

(NOTE: If a capacitor has a bleed resistor connected to its terminals one side will have to be disconnected in order to properly check the capacitor.)

H. Record the condition of each capacitor

I. Have instructor observe the capacitor checking procedure

J. Put away capacitor analyzer and capacitors

ELECTRICAL TEST INSTRUMENTS
UNIT II

JOB SHEET #7 TEST A CAPACITOR WITH AN OHMMETER

I. Tools and materials

   A. Safety glasses

   B. Ohmmeter with an Rx10K scale or above

   C. Bleed resistor

   D. Run capacitors

   E. Start capacitors

II. Procedure

   A. Put on safety glasses

   B. Discharge capacitor with bleed resistor

   (NOTE: Capacitors must be discharged before they can be checked with an ohmmeter to prevent damage to the meter.)

   C. Touch meter leads to capacitor terminals

   (NOTE: If the capacitor has a permanent bleed resistor connected to the terminals one side of it must be disconnected.)

   D. Watch for one of the following indications of the condition of the capacitor:

      1. Good--Needle will swing towards zero and then slowly return to infinity

      2. Shorted--Needle will swing toward zero and remain there

      3. Open--Needle will stay at infinity

      4. Leaky--Needle will swing towards zero and then return to a definite resistance and stay there

      5. Grounded run capacitor--Touch one meter lead to an unpainted spot on the metal can and the other lead to each terminal; any needle movement indicates a defective capacitor

   E. Make a second check by reversing the leads at the capacitor terminals

   F. Write down the condition of each capacitor

   G. Have the instructor observe your work

   H. Put away meter and materials

ELECTRICAL TEST INSTRUMENTS
UNIT II

NAME ______________________

TEST

1. Match the terms on the right to the correct definitions.

_____a. Main power supply

_____b. To align meter needle over zero on the ohm scale

_____c. Limits of a particular portion of a meter

_____d. Insulated ends on a test instrument's leads that are held while checking a circuit

_____e. To adjust a meter so that the needle is properly aligned to the proper set point on the scale

_____f. Complete circuit in which current can flow

_____g. Total current a device draws when it is running fully loaded

_____h. Extreme end of the ohm scale; designated by ∞

_____i. Amperage a motor would draw when the rotor is not turning with power applied

_____j. Resistor connected between capacitor terminals to minimize arcing of the relay points; 20,000 ohm 2 watt carbon resistor

1. Full load amperage (F.L.A.)
2. Line voltage
3. Zero
4. Range
5. Probes
6. Calibrate
7. Locked rotor amperage (L.R.A.)
8. Infinity (infinite resistance)
9. Continuity
10. Bleed resistor

2. List ten safety rules pertaining to electrical test instruments.

a.

b.

c.

d.

e.

f.

g.

h.

i.

j.

3. List five general rules for the protection of electrical test instruments.

a.

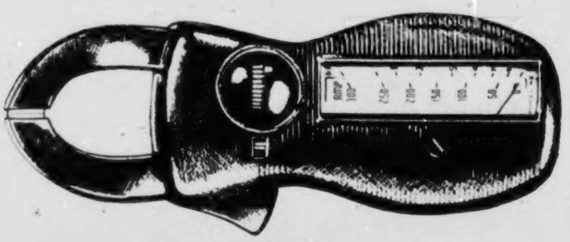
b.

c.

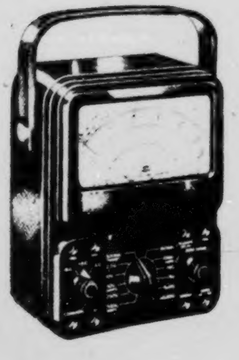
d.

e.

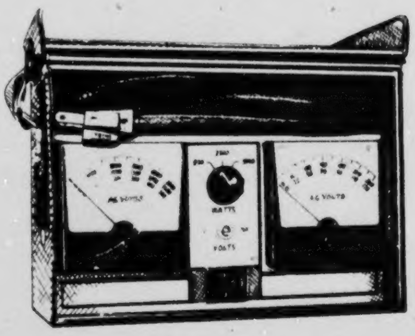
4. Identify the electrical test instruments.



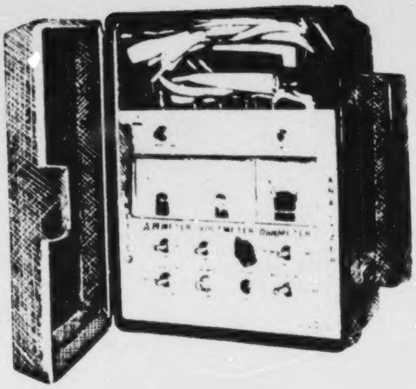
a. ______________________________



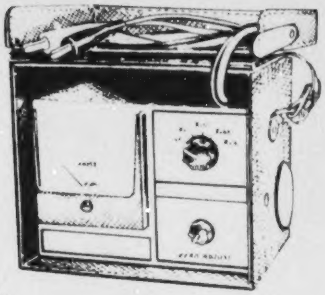
b. ______________________________



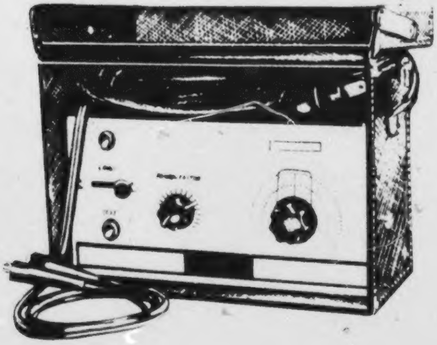
c. ______________________________


AMMETER VOLTMETER OHMMETER

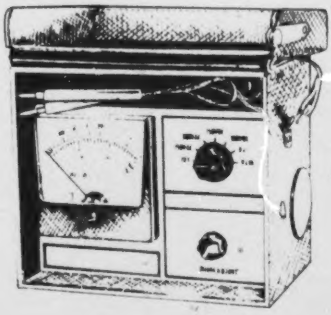
d. ____________________



e. ____________________



f. ____________________



g. ____________________

5. Match the meters on the right to the correct applications.

_____a. Measures line voltage; measures voltage drop at the load; measures low voltage; indicates open components

_____b. AC voltmeter; DC voltmeter; ohmmeter; milliammeter

_____c. Indicates line voltage; indicates starting watts; indicates running watts

_____d. Measures capacitance value; measures power factor; indicates open capacitors; indicates shorted capacitors; indicates leaky capacitors

_____e. Checks for a path for current flow; checks for resistance to current flow; determines motor windings; checks for shorts and grounds; checks capacitors

_____f. Checks compressor for grounds; checks compressor for open windings; may be used to start a locked rotor compressor; starts and runs a compressor

_____g. Checks starting amperage; checks running amperage; checks locked rotor amperage

1. Ohmmeter
2. Capacitor analyzer
3. Voltmeter
4. Wattmeter
5. Multimeter
6. Hermetic analyzer
7. Ammeter

6. List two steps for reading a meter scale.

a.

b.

7. Discuss three circuit conditions.

   a. Open circuit

   b. Short circuit

   c. Grounded circuit

8. Describe the procedure for zeroing the ohmmeter.

   a.

   b.

   c.

   d.

   e.

9. Demonstrate the ability to:
   a. Read a voltmeter scale.
   b. Read an ammeter scale.
   c. Read an ohmmeter scale.
   d. Determine start, run, and common of a single-phase motor.
   e. Use a voltmeter.
   f. Use an ohmmeter.
   g. Use a wattmeter.
   h. Use an ammeter.
   i. Use a hermetic analyzer.
   j. Use a capacitor analyzer.
   k. Test a capacitor with an ohmmeter.

(NOTE: If the above activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

ELECTRICAL TEST INSTRUMENTS
UNIT II

ANSWERS TO TEST

1. a. 2
   b. 3
   c. 4
   d. 5
   e. 6
   f. 9
   g. 1
   h. 8
   i. 7
   j. 10

2. a. Stand on dry, nonconductive surfaces when testing live circuits
   b. Be sure the power is off when checking a circuit with an ohmmeter
   c. Do not use meter leads with defective probes
   d. Do not have both hands in a high voltage cabinet
   e. Do not touch metal cabinet or other grounded material
   f. Wear eye protection
   g. Use fuse pullers
   h. Do not work on live voltage circuits by yourself
   i. Do not assume that the power is off
   j. Discharge capacitors with a bleed resistor before removing or testing

3. Any five of the following:
   a. Keep stored in proper cases
   b. Avoid bumping or jolting
   c. Use only for intended purpose
   d. Use within meter range limits
   e. Avoid exposure to extreme temperatures
   f. Keep clean
   g. Keep dry
   h. Set meter in highest range prior to taking reading

4. a. Ammeter
   b. Multimeter
   c. Wattmeter
   d. Hermetic analyzer
   e. Ohmmeter
   f. Capacitor analyzer
   g. Voltmeter

5. a. 3
   b. 5
   c. 4
   d. 2
   e. 1
   f. 6
   g. 7

6. a. Read meter in the center two-thirds of the scale for greater accuracy
   b. Count the number of graduations between the major divisions

7. Discussion should include:
   a. Open circuit
      1) Most frequent circuit problem
      2) No path for current flow
      3) Caused by
         a) Pitted contacts
         b) Defective relay coil
         c) Broken wire
         d) Blown fuse
         e) Tripped circuit breaker
         f) Open switch
      4) Voltmeter will indicate voltage across an open

- b. Short circuit
    - 1) Second most frequent circuit problem
    - 2) Electrical circuit that has a lower resistance than intended
    - 3) Indications
        - a) Blown fuses
        - b) Tripped circuit breakers
        - c) Melted wires
        - d) Swollen run capacitor cans
        - e) Blackened terminals
        - f) Burnt case
- c. Grounded circuit
    - 1) A high resistance path that current may take to a common ground
    - 2) May not cause a blown fuse or tripped circuit breaker
    - 3) May be determined with an ohmmeter
        - a) Check from lead or terminal to a common ground
        - b) Meter will indicate a medium to high resistance reading

8. a. Select range
    - b. Hold leads together
    - c. Check to see that the needle moves to the extreme right
    - d. Align the needle directly over "0" on the ohm scale
    - e. Zero ohmmeter each time before using or when changing ranges

9. Performance skills evaluated to the satisfaction of the instructor

ELECTRIC POWER
UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to match terms, arrange in order the steps for distributing power, distinguish between single-phase and three-phase current characteristics and select functions of a transformer. The student should also be able to list three ways of providing ground protection, discuss the types of three-phase supply and read an electric watt-hour meter. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with electric power to the correct definitions.
2. Arrange in order the steps for distributing electric power.
3. Distinguish between single-phase and three-phase current characteristics.
4. List three methods of grounding an electrical circuit.
5. Select the functions of transformers.
6. Discuss the types of three-phase supply.
7. List six major causes and three effects of low line voltage.
8. Demonstrate the ability to read an electric watt-hour meter.

ELECTRIC POWER
UNIT III

SUGGESTED ACTIVITIES

I. Instructor:

  A. Provide student with objective sheet.
  B. Provide student with information and assignment sheets.
  C. Make transparencies.
  D. Discuss unit and specific objectives.
  E. Discuss information and assignment sheets.
  F. Invite a power company representaive to talk to the class.
  G. Reemphasize electrical safety rules covered in Units I and II.
  H. Arrange a field trip to a power plant.
  I. Give test.

II. Student:

  A. Read objective sheet.
  B. Study information sheet.
  C. Complete assignment sheet.
  D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

  A. Objective sheet
  B. Information sheet
  C. Transparency masters
    1. TM 1--Power Distribution
    2. TM 2--Grounding
    3. TM 3--Three Wire Delta

    4. TM 4--Four Wire Delta
    5. TM 5--Four Wire Wye

D. Assignment Sheet #1--Read An Electric Watt-Hour Meter

E. Answers to assignment sheet

F. Test

G. Answers to test

II. Reference--Woodroof, William Walton. *Servicing Comfort Cooling Systems.* Columbus, Ohio: NHAW Home Study Institute, 1974.

ELECTRIC POWER
UNIT III

INFORMATION SHEET

I. Terms and definitions

- A. Single-phase--Alternating current circuit with only two current carrying conductors
- B. Three-phase--Alternating current circuit with three current carrying conductors
- C. "Hot" conductor--Current carrying conductor in a circuit; should be any color other than white, green, or natural grey
- D. Grounded conductor--System or circuit conductor which is intentionally grounded, colored green or bare wire
- E. Neutral--Term used to designate a conductor connected to the center tap of the transformer

  (NOTE: The neutral conductor is a current carrying conductor and should not be confused with the equipment ground, even though they will terminate at the same block.)
- F. Step-up transformer--Tranformer which increases the secondary voltage
- G. Step-down transformer--Transformer which decreases the secondary voltage
- H. Electric watt-hour meter--Meter consisting of four clock-type dials which indicates the number of kilowatt hours used in a given amount of time
- I. Primary voltage--Voltage supplied to the input or primary winding of a transformer
- J. Leg--Term used to designate one conductor of a power supply
- K. Secondary voltage--Output voltage, or the voltage that is supplied from the secondary side of the transformer
- L. Equipment ground--Conductor connected to equipment case and to an intentional ground, colored green or bare wire

II. Power distribution (Transparency 1)

- A. Power generating plant
- B. Step-up transformers

INFORMATION SHEET

C. High line transmission cables across country

D. Substation step-down transformers

E. High line transmission cables within city

F. Step-down transformers on power pole

G. Service to individual home or small business

H. Circuit box

I. Individual circuits

III. Single-phase and three-phase current characteristics

A. Single-phase

1. Two current carrying conductors
2. Generally used for residences and small commercial applications
3. Several voltages from 12 volt to 240 volt
4. Can be taken from a three-phase supply
5. Motors frequently require starting components

B. Three-phase

1. Generally commercial and industrial installations
2. Various combinations of voltages
3. Fewer service problems on motors
4. Can be used to supply single-phase power
5. Needs no motor starting capacitors
6. Voltage balance is important

IV. Methods of grounding an electrical circuit (Transparency 2)

A. Cold water pipes

(NOTE: Be sure that the water pipe does not connect onto a plastic water line.)

B. Metal stake

C. Metal case of main distribution panel

INFORMATION SHEET

V. Functions of transformers

   A. Step-Up

      1. Increases voltage

      2. Decreases current

         (NOTE: By increasing the voltage which in turn will decrease the current, electricity is easily transmitted over long distances with relatively small transmission cable.)

   B. Step-Down

      1. Steps down transmission power line voltage

      2. Increases current

         Example: A modern total electric home would require 30,000 watts. Assume a primary voltage of 600 volts and a secondary voltage 240 volts

         30,000 ÷ 240 = 125 amperes
         Entrance cable into the house must be large enough to carry in excess of 125 amperes

         30,000 watts ÷ 600 VAC = 50 amperes
         Transmission cable to the primary of the transformer only needs to be large enough to carry 50 amperes

VI. Three-phase supply

   A. Three wire delta (Transparency 3)

      1. Voltages–240, 440, or 550

         a. One three-phase circuit

         b. Three single-phase circuits

      2. Grounded or ungrounded

         (NOTE: The grounded transformer is preferable due to safety. When using an ungrounded system all legs must be broken with a contactor.)

   B. Four wire delta (Transparency 4)

      1. Voltages

         a. Two 120 volt single-phase circuits

INFORMATION SHEET

b. One 240 volt three-phase circuit

c. Three 240 volt single-phase circuits

(NOTE: All 120 volt circuits should have approximately the same current load so that the three-phase voltages will not become unbalanced.)

2. A "wild-leg" which is not used for single-phase power

(NOTE: The "wild-leg" or "stinger-leg" as it is sometimes called has a voltage of approximately 200 volts. This conductor should be an orange color.)

C. Four wire wye (Transparency 5)

1. Voltages--208/120 or 480/277

(NOTE: Other voltage combinations are possible with this type of transformer but are not common.)

a. Three 120 volt single-phase circuits

b. Three 208 volt single-phase circuits

c. One 208 volt three-phase circuit

2. Enables easy balancing of circuits

3. Transformer neutral must be used for ground

(NOTE: The use of any other ground to obtain single-phase power may result in low voltage to the load.)

VII. Low line voltage

A. Causes

1. Undersize wire

2. Long runs of wire

3. Loads in series

4. Poor connections

5. Power supply

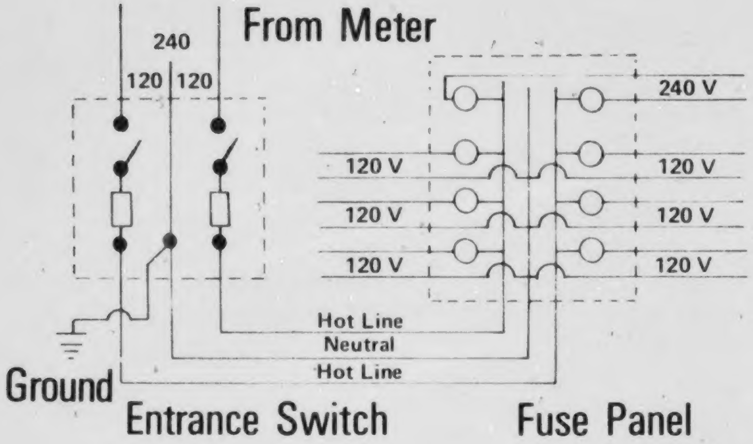
6. Undersize transformer

INFORMATION SHEET

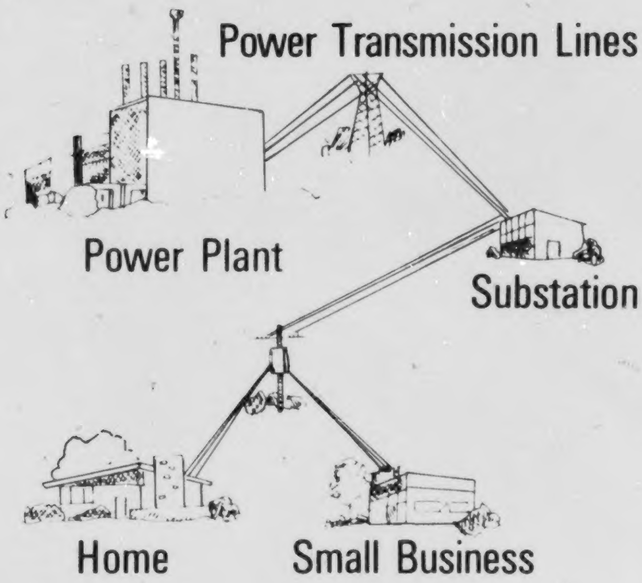
B. Effects on motors

1. Reduces starting torque
2. Reduces running efficiency
3. Increases temperature rise

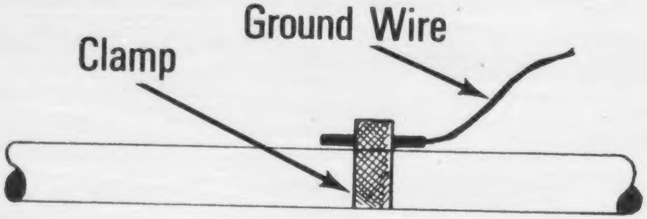
Power Distribution


From Meter
240
120
120
240 V
120 V
120 V
120 V
120 V
120 V
120 V
Hot Line
Neutral
Hot Line
Ground
Entrance Switch
Fuse Panel

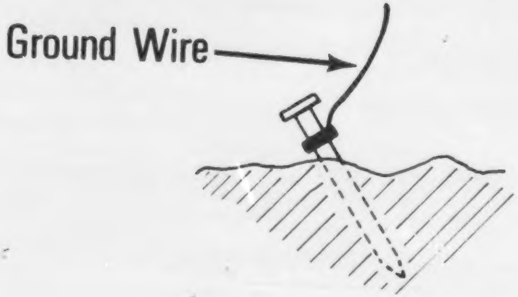
Power Distribution In A Home Or Small Business
Single-Phase


Power Transmission Lines
Power Plant
Substation
Home
Small Business

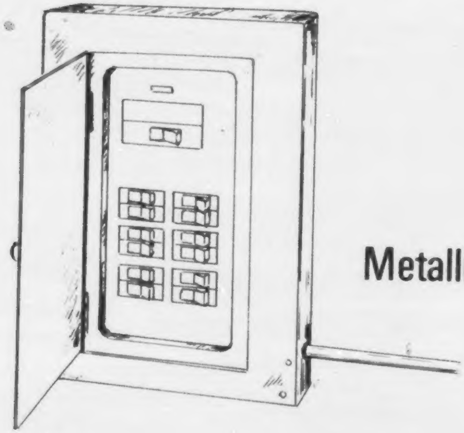
Grounding


Ground Wire
Clamp

Cold Water Pipe


Ground Wire

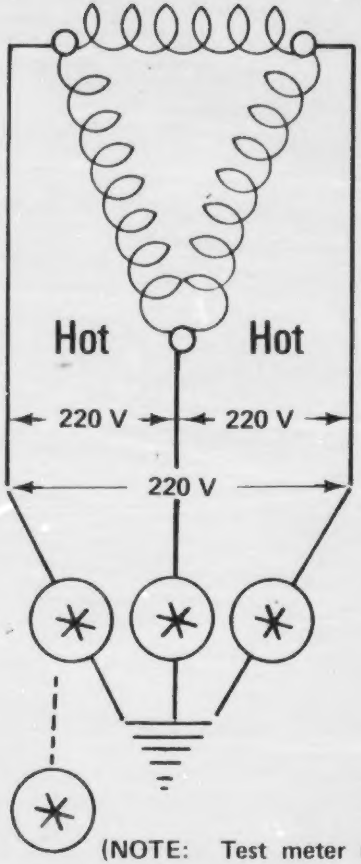
Grounding Rod



Metallic Conduit

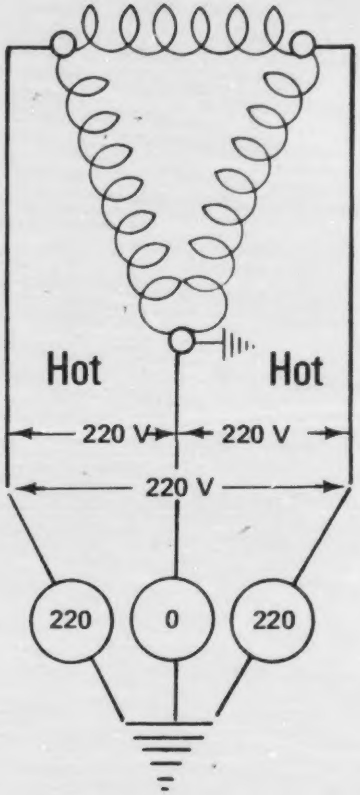
Three Wire Delta

Ungrounded

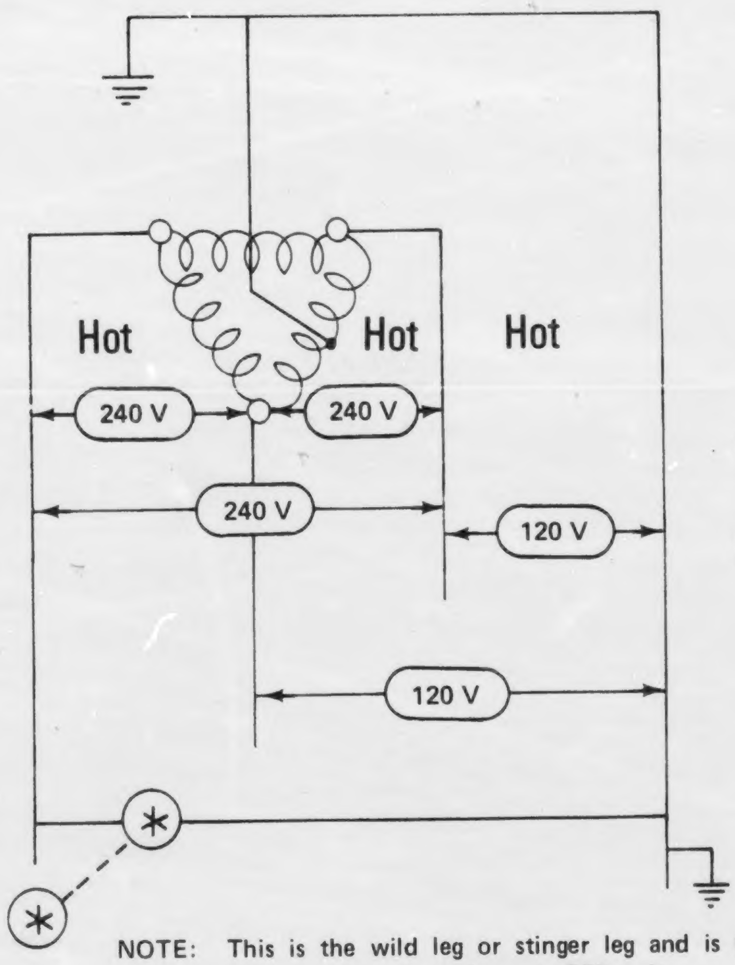

Hot
Hot
220 V
220 V
220 V

(NOTE: Test meter may indicate some voltage reading.)

Grounded

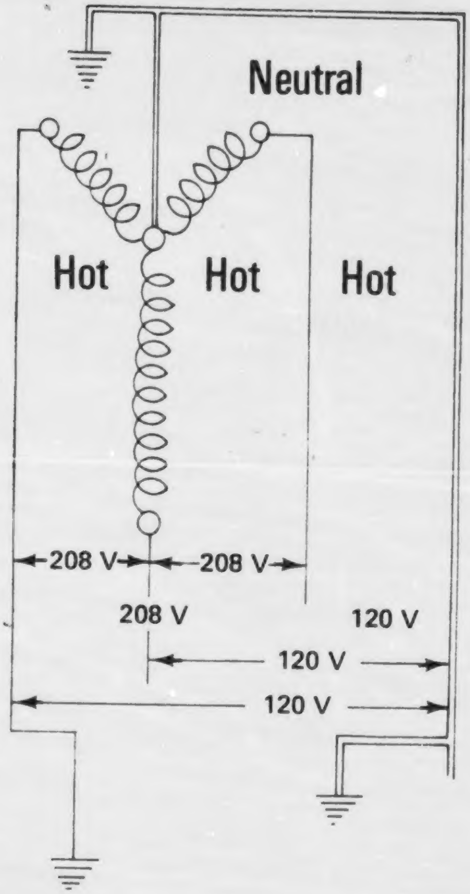

Hot
Hot
220 V
220 V
220 V
220
0
220

Four Wire Delta


Hot
Hot
Hot
240 V
240 V
240 V
120 V
120 V
Ground
*
*

NOTE: This is the wild leg or stinger leg and is not used for 120v single-phase since its voltage is 200 volts.

Four Wire Wye

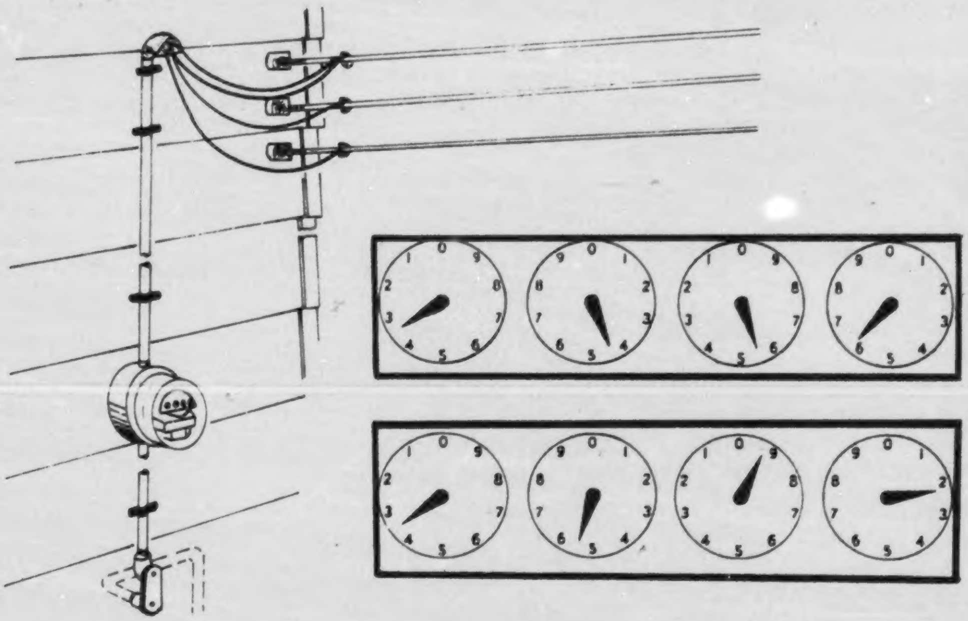

Neutral
Hot
Hot
Hot
208 V
208 V
208 V
120 V
120 V
120 V

ELECTRIC POWER
UNIT III

ASSIGNMENT SHEET #1--READ AN ELECTRIC WATT-HOUR METER

The electric meter on the house indicates how much current has been consumed in a given amount of time. This is determined by reading a series of dials.

Example:



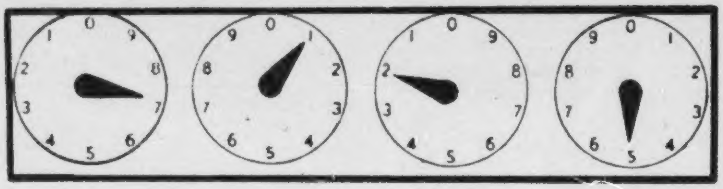
The power company's "Watt-meter" has four dials. Each dial has a hand. Note that two dials read clockwise and two read counter-clockwise.

Write down the number that the hand has just passed on each of the dials in the top row. Suppose the reading on dials is 3456 (KWH) Kilowatt hours as shown above. Let's assume the above figures represent the reading at beginning of the month. Suppose at the end of the month the readings appear as on dials in lower row. Reading as before, we obtain 3592 (KWH) Kilowatt hours. The difference is as follows:

This month's reading	3592
Last month's reading	3456
Kilowatt hours used in month	136

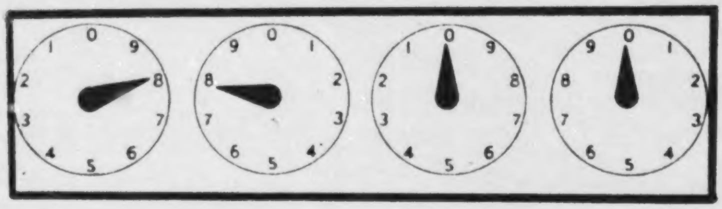
ASSIGNMENT SHEET #1

1. Read the following dials:


0 9 8 7 6 5 4 3 2 1
0 1 2 3 4 5 6 7 8 9
0 9 8 7 6 5 4 3 2 1
0 1 2 3 4 5 6 7 8 9

ans. ______________________

2. Read the following dials:


0 9 8 7 6 5 4 3 2 1
0 1 2 3 4 5 6 7 8 9
0 9 8 7 6 5 4 3 2 1
0 1 2 3 4 5 6 7 8 9

ans. ______________________

3. How many kilowatt hours were consumed between problems one and two?

ans. ______________________

ELECTRIC POWER
UNIT III

ANSWERS TO ASSIGNMENT SHEET

1. 7125
2. 8800
3. 1675

ELECTRIC POWER
UNIT III

NAME______________________________

TEST

1. Match the terms on the right to the correct definitions.

_____a. Output voltage, or the voltage that is supplied from the secondary side of the transformer

_____b. Term used to designate a conductor connected to the center tap of the transformer

_____c. Current carrying conductor in a circuit; should be any color other than white, green, or natural grey

_____d. Alternating current circuit with three current carrying conductors

_____e. System or circuit conductor which is intentionally grounded, colored green or bare wire

_____f. Term used to designate one conductor of a power supply

_____g. Meter consisting of four clock-type dials which indicates the number of kilowatt hours used in a given amount of time

_____h. Voltage supplied to the input or primary winding of a transformer

_____i. Alternating current circuit with only two current carrying conductors

_____j. Transformer which decreases the secondary voltage

_____k. Transformer which increases the secondary voltage

_____l. Conductor connected to equipment case and to an intentional ground, colored green or bare wire

1. Electric watt-hour meter
2. Step-down transformer
3. Equipment ground
4. Neutral
5. Three-phase
6. Step-up transformer
7. Primary voltage
8. Grounded conductor
9. Single-phase
10. "Hot" conductor
11. Secondary voltage
12. Leg

2. Arrange in order the steps for distributing electric power by placing the correct sequence numbers in the appropriate blanks, beginning with point of origin and going to point of termination.

______a. High line transmission cables across country

______b. Circuit box

______c. Step-up transformers

______d. Individual circuits

______e. Substation step-down transformers

______f. Power generating plant

______g. Service to individual home or small business

______h. High line transmission cables within city

______i. Step-down transformers on power pole

3. Distinguish between single-phase and three-phase currents by placing an "S" in front of the single-phase characteristics and a "T" in front of the three-phase characteristics.

______a. Two current carrying conductors

______b. Fewer service problems on motors

______c. Can be taken from a three-phase supply

______d. Generally used for residences and small commercial applications

______e. Generally commercial and industrial installations

______f. Several voltages from 12 volt to 240 volt

______g. Needs no motor starting capacitors

______h. Motors frequently require starting components

______i. Voltage balance is important

______j. Can be used to supply single-phase power

4. List three methods of grounding an electrical circuit.

a.

b.

c.

5. Select the functions of transformers by placing an "X" in the appropriate blanks.

______a. Increases voltage

______b. Rectifies direct current electricity

______c. Converts amperes to kilowatt hours

______d. Increases current

______e. Steps-down transmission power line voltage

______f. Changes 60 hertz current to 60 cycle current

______g. Decreases current

6. Discuss the types of three-phase supply.

7. List six major causes and three effects of low line voltage.

   a. Causes

      1.

      2.

      3.

      4.

      5.

      6.

   b. Effects

      1.

      2.

      3.

8. Demonstrate the ability to read an electric watt-hour meter.

   (NOTE: If this activity has not been accomplished prior to the test, ask your instructor when it should be completed.)

ELECTRIC POWER
UNIT III

ANSWERS TO TEST

1.	a.	11	g.	1
	b.	4	h.	7
	c.	10	i.	9
	d.	5	j.	2
	e.	8	k.	6
	f.	12	l.	3
2.	a.	3	f.	1
	b.	8	g.	7
	c.	2	h.	5
	d.	9	i.	6
	e.	4		
3.	a.	S	f.	S
	b.	T	g.	T
	c.	S	h.	S
	d.	S	i.	T
	e.	T	j.	T

4. a. Cold water pipes
   b. Metal stake
   c. Metal case of main distribution panel

5. a, d, e, g

6. Discussion should include:
   a. Three wire delta
      1) Voltages--240, 440 or 550
         a) One three-phase circuit
         b) Three single-phase circuits

            2) Grounded or ungrounded

    b. Four wire delta

        1) Voltages

            a) Two 120 volt single-phase circuits

            b) One 240 volt three-phase circuit

            c) Three 240 volt single-phase circuits

        2) A "wild-leg" which is not used for single-phase power

    c. Four wire wye

        1) Voltages--208/120 or 480/277

            a) Three 120 volt single-phase circuits

            b) Three 208 volt single-phase circuits

            c) One 208 volt three-phase circuit

        2) Enables easy balancing of circuits

        3) Transformer neutral must be used for ground

7. a. Causes

        1. Undersize wire

        2. Long runs of wire

        3. Loads in series

        4. Poor connections

        5. Power supply

        6. Undersize transformer

    b. Effects on motors

        1. Reduces starting torque

        2. Reduces running efficiency

        3. Increases temperature rise

8. Performance skills evaluated to the satisfaction of the instructor

BASIC ELECTRIC THERMOSTATS
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to match terms to their correct definitions or descriptions and identify types of thermostats and their components. The student should also be able to demonstrate the ability to determine heat anticipation and install a wall thermostat. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with thermostats to the correct definitions or descriptions.
2. Name three types of thermostats.
3. Identify parts of a low voltage thermostat.
4. Identify parts of a millivolt thermostat.
5. Identify parts of a line voltage thermostat.
6. Identify types of thermostat contacts.
7. Identify shapes of thermostatic bimetals.
8. Discuss the operation of a thermostatic bimetal.
9. Discuss thermostat anticipation.
10. Discuss the characteristics of a two-stage thermostat.
11. Discuss the advantages of time controlled thermostats.
12. Select guidelines for correctly installing a room thermostat.
13. List the applications of low voltage, millivolt, and line voltage thermostats.
14. Match the low voltage thermostat subbase terminal markings to the proper component.

15. Demonstrate the ability to:
    a. Wire mercury bulb to correct terminals.
    b. Determine heat anticipation.
    c. Install a wall thermostat.

BASIC ELECTRIC THERMOSTATS
UNIT I

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information, assignment, and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information and assignment sheets.

   F. Demonstrate and discuss the procedures outlined in the job sheets.

   G. Show students actual thermostats and components.

   H. Construct a practice thermostat wiring board.

   I. Discuss the adjusting of wall thermostats.

   J. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Complete assignment and job sheets.

   D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM 1--Low Voltage Thermostat Parts

      2. TM 2--Millivolt Thermostat Parts

      3. TM 3--Line Voltage Thermostat Parts

        4. TM 4--Thermostat Contacts
        5. TM 5--Bimetals
        6. TM 6--Thermostat Subbases
    D. Assignment Sheet #1--Wire Mercury Bulb to Correct Terminals
    E. Answers to assignment sheet
    F. Job sheets
        1. Job Sheet #1--Determine Heat Anticipation
        2. Job Sheet #2--Install a Wall Thermostat
    G. Test
    H. Answers to test

II. References:

A. *Heating and Cooling Controls.* Columbus, Ohio: NHAW Home Study Institute, 1972.

B. Russell, Allen. *Getting Started in Heating and Air Conditioning Service.* Birmingham, Michigan: Business News Publishing Co., 1973.

C. Langley, B. C. *Electric Controls for Refrigeration and Air Conditioning.* Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1974.

D. Althouse, Andrew D., Tunquist, Carl H., and Bracciano, Alfred F. *Modern Refrigeration and Air Conditioning.* Homewood, Illinois: Goodheart-Willcox Company, Inc., 1975.

BASIC ELECTRIC THERMOSTATS
UNIT I

INFORMATION SHEET

I. Terms and definitions or descriptions

  A. Bimetal--Two metallic alloys bonded together which have different rates of expansion and will warp when exposed to a temperature change

  B. Heat anticipator--A small, usually variable resistor in series with the thermostat contacts and load which will generate a small amount of heat and cause the contacts to open early

  C. Mercury bulb--Thermostat contacts consisting of a small amount of liquid mercury sealed in a glass tube

  D. Low voltage--A 24 V.A.C. circuit in air-conditioning and refrigeration controls

  E. Bellows--A corrugated cylindrical container which moves as pressures change

  F. Line voltage--Generally above 50 V.A.C. in air-conditioning and refrigeration controls

  G. Thermostat--Device which senses temperature conditions and, in turn, acts to control a circuit

  H. Millivolt--Voltage which is generated by a thermocouple; used for heating only

  (NOTE: A millivolt is one thousandth of a volt, and in heating systems the usual range is 35 to 750 millivolts.)

  I. Invar--Metal which is an iron and nickel alloy

  J. Subbase--Portion of the thermostat that is attached to the wall and to which all thermostat wiring connections are made

  K. Cooling anticipator--Generally a fixed resistor wired parallel to the cooling contacts which will generate a small amount of heat and cause the contacts to close early

II. Types of thermostats

  A. Low voltage

  B. Millivolt

INFORMATION SHEET

C. Line voltage

(NOTE: All line voltage wiring should be done according to the National Electric Code.)

1. Heating or cooling

2. Refrigeration

III. Parts of a low voltage thermostat (Transparency 1)

A. Bimetal temperature sensing elements

(NOTE: This is generally a bimetal.)

B. Electrical contacts

1. Mechanical points

(NOTE: These are snap action points which help to prevent arcing.)

2. Mercury bulb

C. Manual temperature selector

D. Adjustable heat anticipator

E. Cooling anticipator

F. Cover

G. Thermometer

H. Subbase

(NOTE: Be sure the subbase matches the equipment.)

I. Manual switches

1. Fan switch

2. System switch

IV. Parts of a millivolt thermostat (Transparency 2)

A. Bimetal temperature sensing element

B. Electrical contacts

1. Mechanical points

2. Mercury bulb

INFORMATION SHEET

- C. Manual temperature selector
- D. Heat anticipator
- E. Cover
- F. Thermometer
- G. Subbase

V. Parts of a line voltage thermostat (Transparency 3)

- A. Temperature sensing element
    - 1. Bimetal
    - 2. Gas/liquid filled bulb
- B. Electrical contacts
- C. Range adjustment knob
- D. Differential adjustment screws
    - 1. Cut-in
    - 2. Cut-out

VI. Thermostat contacts (Transparency 4)

- A. Snap action
    - 1. Single pole single throw
    - 2. Single pole double throw

  (NOTE: Some snap action thermostats will use a magnet at the contacts to make them close quicker and prevent arcing of the points.)

- B. Mercury bulb
    - 1. Single pole single throw
    - 2. Single pole double throw

  (NOTE: These mercury bulbs are vacuum sealed to prevent arcing.)

INFORMATION SHEET

VII. Shapes of thermostatic bimetals (Transparency 5)

- A. Helix
- B. Cantilever
- C. "U" shaped
- D. Spiral
- E. Snap-disc

VIII. Operation of a thermostatic bimetal

- A. Two different metals bonded together
  - 1. Brass--Expands rapidly
  - 2. Invar--Expands slowly
- B. Warps when heated or cooled due to different rates of expansion
- C. Warping action causes opening or closing of thermostat contacts

IX. Thermostat anticipation

- A. Heating
  - 1. Thermostats with bimetal sensing elements
  - 2. In series with thermostat contacts
  - 3. Two types
    - a. Fixed--Carbon resistor
    - b. Adjustable--Variable resistor
  - 4. Setting determined by current draw of load
    - a. Gas valve solenoid
    - b. Electric heater contactor

(CAUTION: Never bypass the control load with a jumper wire or other device, as this will cause the heat anticipator to open. This may also cause the anticipator to overheat and cause a fire.)

(NOTE: The anticipator on a millivolt thermostat must be placed directly against the bimetal. These should only be used on 750 millivolt systems.)

INFORMATION SHEET

B. Cooling

1. Generally low voltage wall thermostats
2. Carbon resistors

(NOTE: It is possible to change these anticipators, but check with the thermostat manufacturer before changing.)

3. Resistance of anticipator is determined by the current draw of the contactor coil
4. Parallel to thermostat contacts

X. Characteristics of a two-stage thermostat

A. Cooling

1. Controls two cooling capacities
2. Two switches on one bimetal, usually mercury bulbs
3. Two degree differential between switches
4. First stage closes at approximately 2°F above the "set" temperature
5. If termperature continues to rise second stage will close at approximately 4°F above "set" temperature
6. Both switches will be open at "set" temperature

B. Heating

1. Used for the following heating situations:
    a. Gas heating with dual gas valves
    b. Electric furnaces with extra strips
    c. Heat pumps with electric strips for supplementary heat
2. Two switches on one bimetal, usually mercury bulbs
3. Two degree differential between switches
4. First stage closes at approximately 2°F below the "set" temperature
5. If temperature continues to drop second stage will close at approximately 4°F below "set" temperature
6. Both switches will be open at set temperature

INFORMATION SHEET

C. Combinations

1. Two-stage cooling and single-stage heat
2. Two-stage heat and single-stage cooling

XI. Advantages of time controlled thermostats

A. Automatically lowers temperature at night

1. Provides more comfortable sleeping
2. Conserves energy
    a. Summer by lowering temperature at night when equipment runs more efficiently
    b. Winter by reducing the on time of heating equipment

B. Automatically increases temperature during the day

C. Convenient in winter because the increase in temperature occurs early before the occupant arises

XII. Guidelines for installing a wall thermostat

A. Seal the wire opening in the wall

B. Must be level

C. Locate in conditioned area

D. Must have normal air circulation

(NOTE: Do not locate the thermostat behind a door or other dead air space.)

E. Locate on inside wall approximately 4' 6" to 5' above floor

F. Keep away from sources of artificial heat or cold such as:

1. Television sets
2. Lamps
3. Direct sunlight
4. Drafts
5. Walls adjacent to bathrooms
6. Kitchen walls

INFORMATION SHEET

XIII. Applications of thermostats

A. Low voltage

1. Central heating systems
2. Central cooling systems

B. Millivolt

(NOTE: This type of thermostat is used primarily on gas heating equipment.)

1. Wall heaters
2. Floor furnaces
3. Central heaters

   (NOTE: The majority of the central heaters have low voltage thermostats.)

C. Line voltage

1. Window air conditioners
2. Domestic refrigeration
3. Commercial refrigeration
4. Industrial air conditioners
5. Ventilators

XIV. Thermostat subbase terminal markings (Transparency 6)

A. "V" or "R"--Power supply

B. "F" or "G"--Fan

C. "H" or "W"--Heat on single stage

D. "C" or "Y"--Cooling on single stage

E. "H_1" or "W_1"--First stage on two stage heat

F. "H_2" or "W_2"--Second stage on two stage heat

G. "C_1" or "Y_1"--First stage on two stage cooling

H. "C_2" or "Y_2"--Second stage on two stage cooling

(NOTE: The majority of the thermostat manufacturers are now using the R, G, W, and Y markings but not all of them. The two systems are never mixed together.)

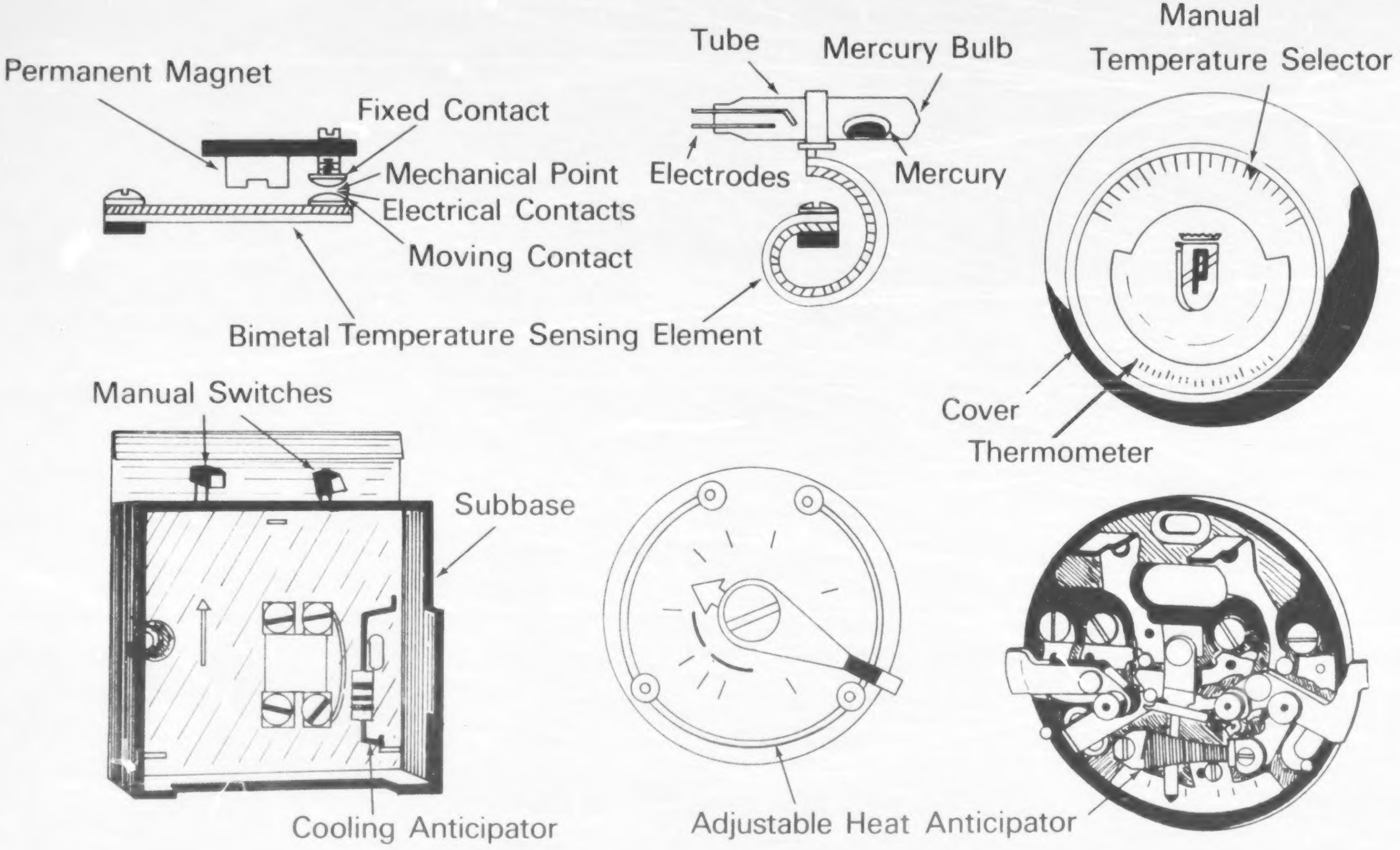
INFORMATION SHEET

I. Rh--Power heating transformer

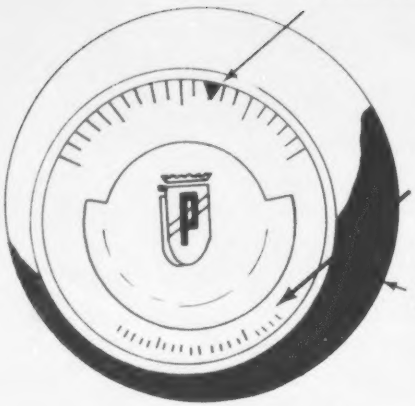
J. Rc--Power cooling transformer

(NOTE: Some systems are separate control power transformers, and the Rh is the power for the heating system and Rc would be the power for the cooling system. If this type of subbase is used on a system with one transformer, the Rh and Rc must be connected together.)

Low Voltage Thermostat Parts


Permanent Magnet
Fixed Contact
Mechanical Point
Electrical Contacts
Moving Contact
Bimetal Temperature Sensing Element
Tube
Mercury Bulb
Electrodes
Mercury
Manual
Temperature Selector
Cover
Thermometer
Manual Switches
Subbase
Cooling Anticipator
Adjustable Heat Anticipator

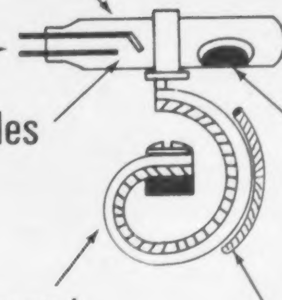
Millivolt Thermostat Parts



Manual Temperature Selector

Thermometer

Cover



Tube

Mercury Bulb

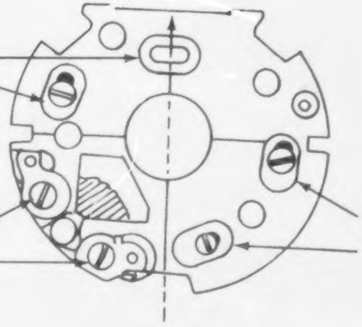
Electrical Contacts

Electrodes

Mercury

Bimetal

Heat Anticipator

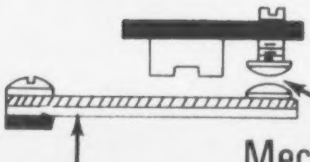


Mounting Holes

Terminal Screws

Mounting Holes

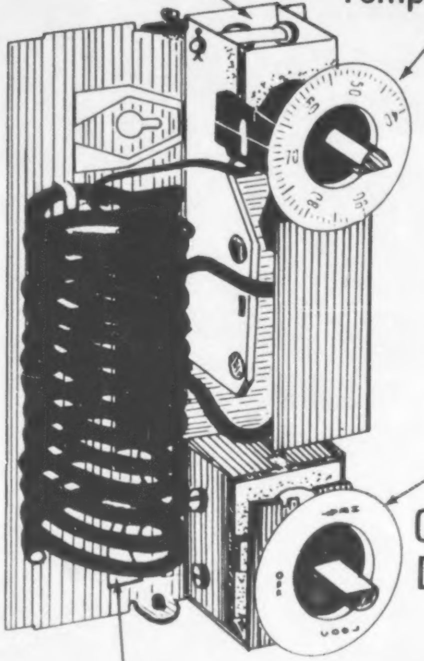
Subbase



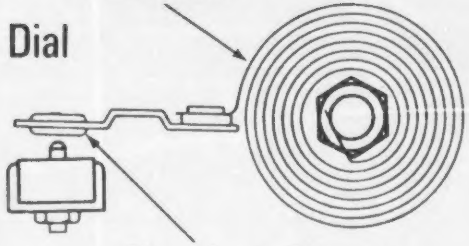
Mechanical Points

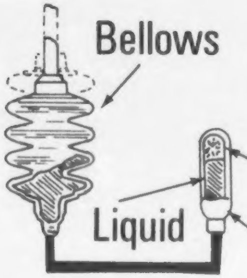
Bimetal Temperature Sensing Element

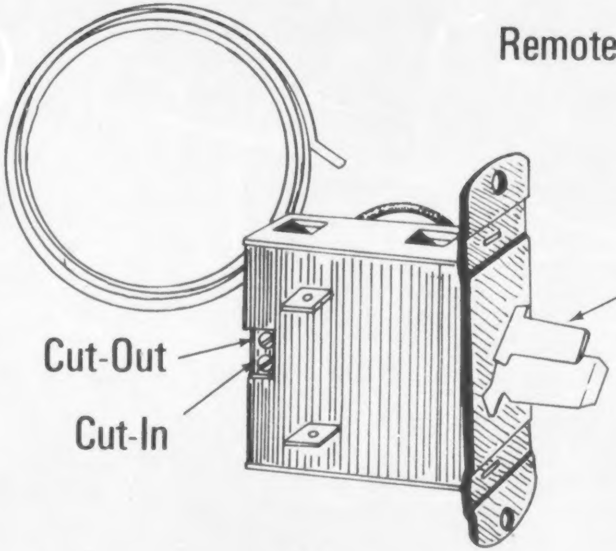
Line Voltage Thermostat Parts


Bellows
Temperature Dial
Heating Or Cooling Selection Dial
Thermal Sensitive Tubing

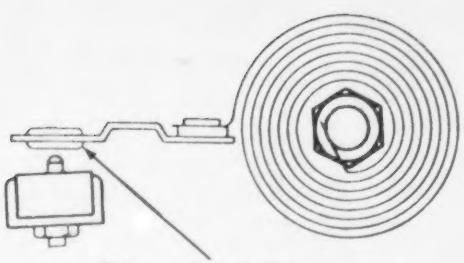
Heat/Cool Thermostat


Bimetal
Electrical Contacts

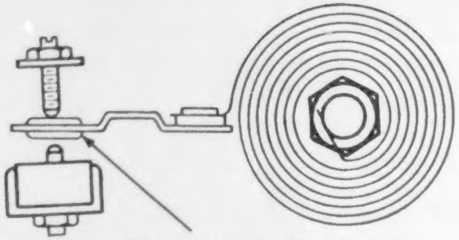

To Temp. Controller Mechanism
Bellows
Pressure
Liquid
Remote Temp. Sensing Bulb


Range Adjustment
Cut-Out
Cut-In

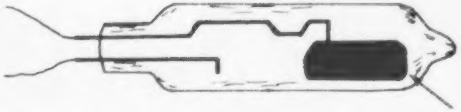
Thermostat Contacts


Electrical Contacts

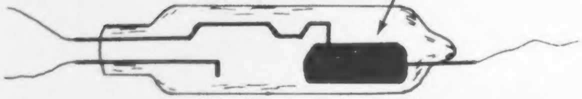
Single Pole Single Throw


Snap Action
Electrical Contacts

Single Pole Double Throw

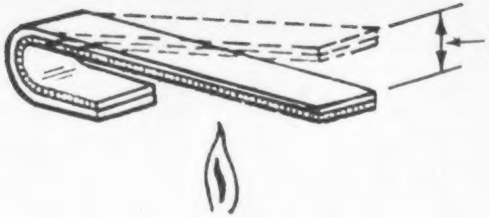

Mercury Bulb
Mercury Globule

Single Pole Single Throw

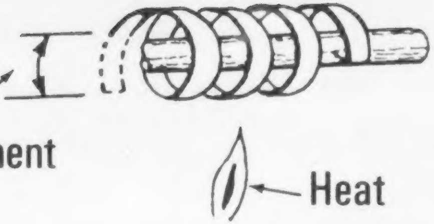

Mercury Globule

Single Pole Double Throw

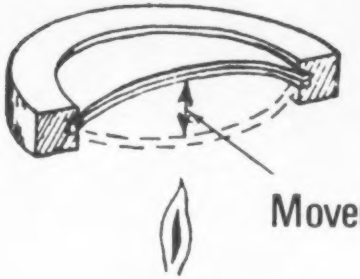
Bimetals



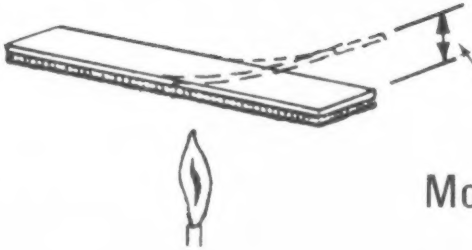
'U' Shaped


Rotary Movement
Heat

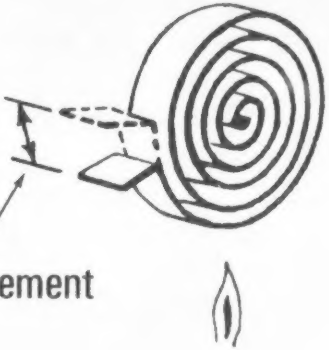
Helix



Snap-Disc

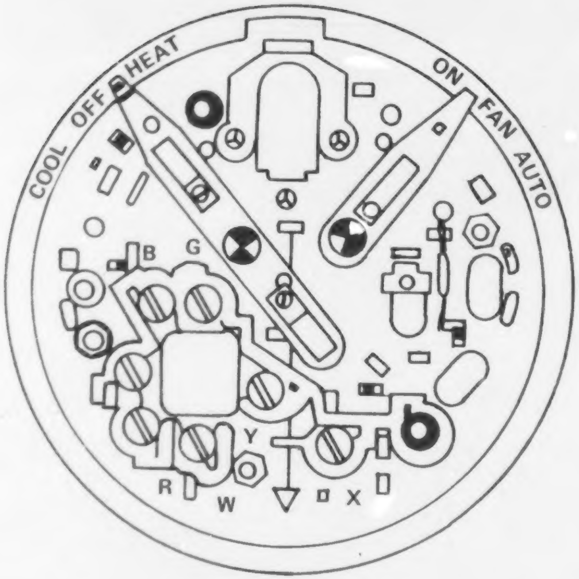

Movement (Warpage)

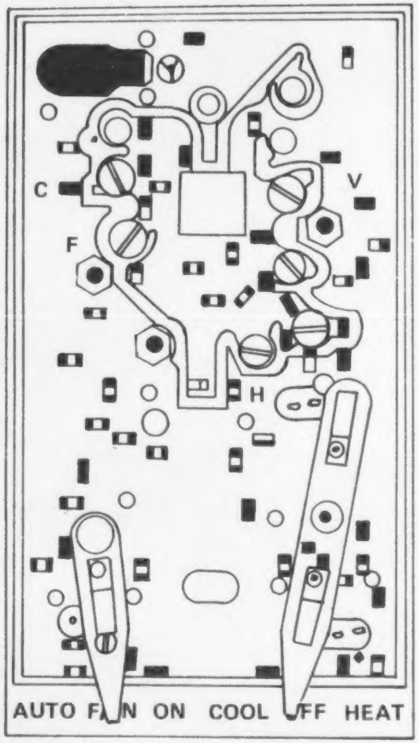
Cantilever


Rotary Movement

Spiral

Thermostat Subbases

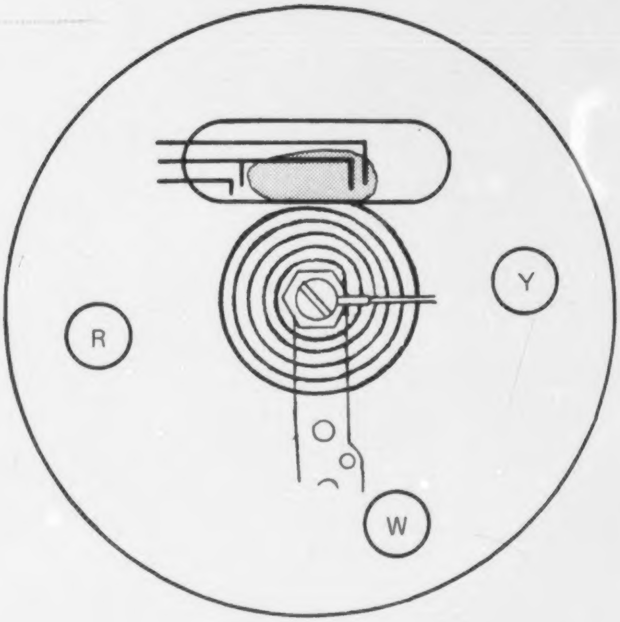

COOL
OFF
HEAT
ON
FAN
AUTO
B
G
Y
R
W
X


C
V
F
H
AUTO FAN ON
COOL OFF HEAT

BASIC ELECTRIC THERMOSTATS
UNIT I

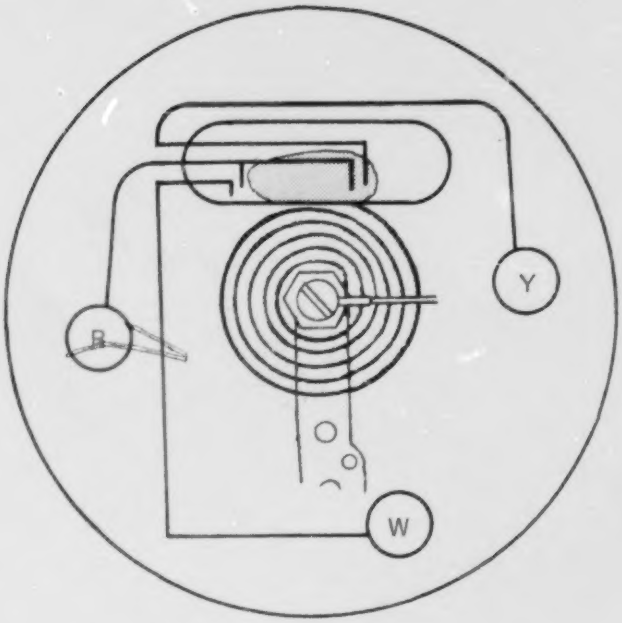
ASSIGNMENT SHEET #1--WIRE MERCURY BULB TO CORRECT TERMINALS

On the drawing below connect the mercury bulb leads to the correct terminals. Remember, the bimetal will coil tighter as it cools.



BASIC ELECTRIC THERMOSTATS
UNIT I

ANSWER TO ASSIGNMENT SHEET



BASIC ELECTRIC THERMOSTATS
UNIT I

JOB SHEET #1--DETERMINE HEAT ANTICIPATION

I. Tools and materials

   A. Ammeter

   B. Coil of wire--10 loops

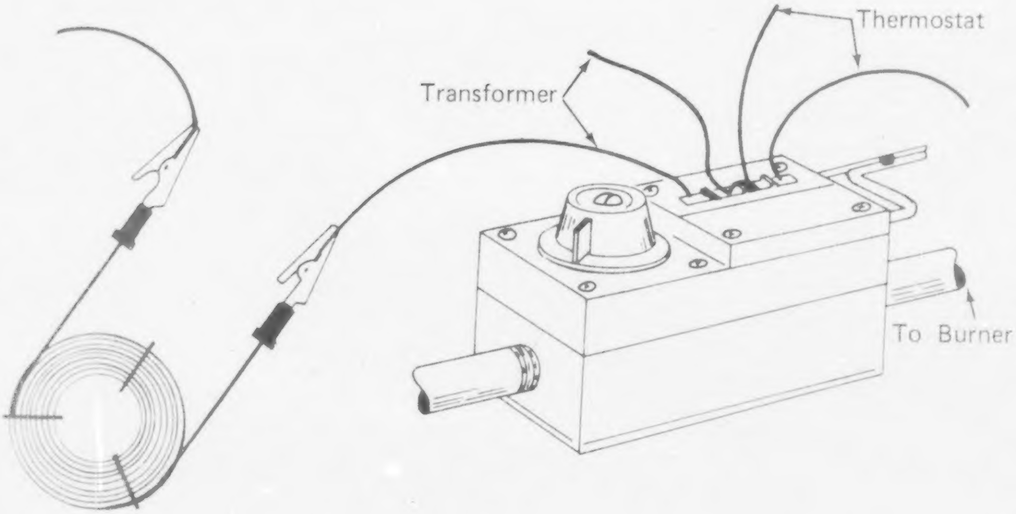
   C. Heating unit with 24v control

II. Procedure

   A. Disconnect power from heater

   B. Place coil of wire in series with one side of heating control (Figure 1)

   (NOTE: This may be either a gas valve or an electric relay.)

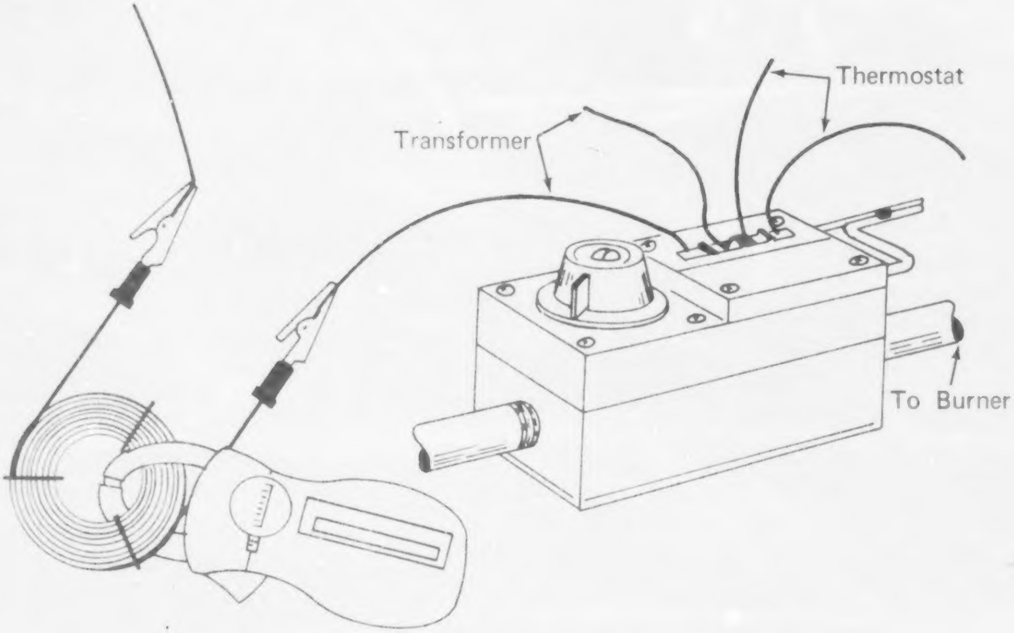


   C. Turn on power

   D. Increase thermostat setting above the ambient

JOB SHEET #1

E. Clamp ammeter through the coil of wire (Figure 2)



F. Take ammeter reading

G. Divide the reading by ten

Example: Ammeter reading 4
4 ÷ 10 = .4

(NOTE: This is the normal anticipator setting.)

H. Set heat anticipator on thermostat

(NOTE: Most manufacturers of heating controls will print the ampere draw of the control on the side but in case it is not the above procedure may be used to determine it.)

I. Turn off heating unit

J. Disconnect electrical power

K. Have instructor check the anticipator setting

L. Clean-up and put away tools

BASIC ELECTRIC THERMOSTATS
UNIT I

JOB SHEET #2--INSTALL A WALL THERMOSTAT

I. Tools and materials

   A. Flat tip screwdriver

   B. Scratch awl

   C. Wire strippers

   D. Pocket screwdriver

   E. Screw starter

   F. Heat-cool thermostat subbase

   G. Heat-cool thermostat

   H. Four conductor thermostat wire

   I. Level

II. Procedure

   A. Locate area on wall for thermostat

   B. Measure up from floor 54 to 60 inches

   C. Mark a spot to center subbase

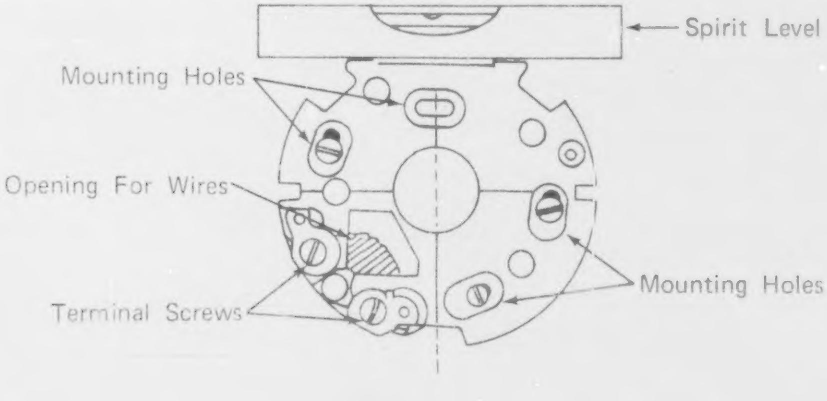
   D. Hold subbase up to wall and center it

   E. Place level on subbase

   F. Check for approximate level

   (NOTE: A plumb bob is sometimes used for additional accuracy.)

   G. Mark spots for mounting screws (Figure 1)


Spirit Level
Mounting Holes
Opening For Wires
Mounting Holes
Terminal Screws

JOB SHEET #2

H. Mark spots in the center of the elongated slots

I. Move subbase

J. Use scratch awl to make screw holes

K. Place subbase on wall

L. Start screws

M. Check for level

N. Tighten screws and recheck level

O. Bring thermostat wire through the proper opening

P. Do not have any wires crossing the center of the subbase

Q. Strip 1/2" of insulation off of each conductor

R. Connect red wire to "R" or "V" terminal

S. Connect white wire to "W" or "H" terminal

T. Connect green wire to "G" or "F" terminal

U. Connect yellow wire to "Y" or "C" terminal

(NOTE: Some wire manufacturers have a blue wire instead of a yellow wire in their thermostat cable.)

V. Push the wires back so that they will not interfere with the thermostat

W. Seal the opening through which the wires entered

X. Have instructor check your work

Y. Align thermostat on subbase

(NOTE: Be sure thermostat is properly aligned before tightening to prevent cracking.)

Z. Tighten thermostat screws

(NOTE: When removing a thermostat from a subbase leave the screws in the retainers in the thermostat.)

AA. Place cover on thermostat

(NOTE: If this is on a live system turn on power and check operation.)

BB. Clean up and put away tools and equipment

BASIC ELECTRIC THERMOSTATS
UNIT I

NAME ____________________________

TEST

1. Match the terms on the right to the correct definitions or descriptions.

______a. Generally above 50 V.A.C. in air-conditioning and refrigeration controls

______b. Two metallic alloys bonded together which have different rates of expansion and will warp when exposed to a temperature change

______c. Voltage which is generated by a thermocouple; used for heating only

______d. A corrugated cylindrical container which moves as pressures change

______e. Portion of the thermostat that is attached to the wall and to which all thermostat wiring connections are made

______f. Device which senses temperature conditions and, in turn, acts to control a circuit

______g. Thermostat contacts consisting of a small amount of liquid mercury sealed in a glass tube

______h. Metal which is an iron and nickel alloy

______i. A 24 V.A.C. circuit in air-conditioning and refrigeration controls

______j. A small, usually variable resistor in series with the thermostat contacts and load which will generate a small amount of heat and cause the contacts to open early

______k. Generally a fixed resistor wired parallel to the cooling contacts which will generate a small amount of heat and cause the contacts to close early

1. Thermostat
2. Heat anticipator
3. Millivolt
4. Subbase
5. Bellows
6. Mercury bulb
7. Invar
8. Line voltage
9. Bimetal
10. Low voltage
11. Cooling anticipator

2. Name three types of thermostats.

   a.

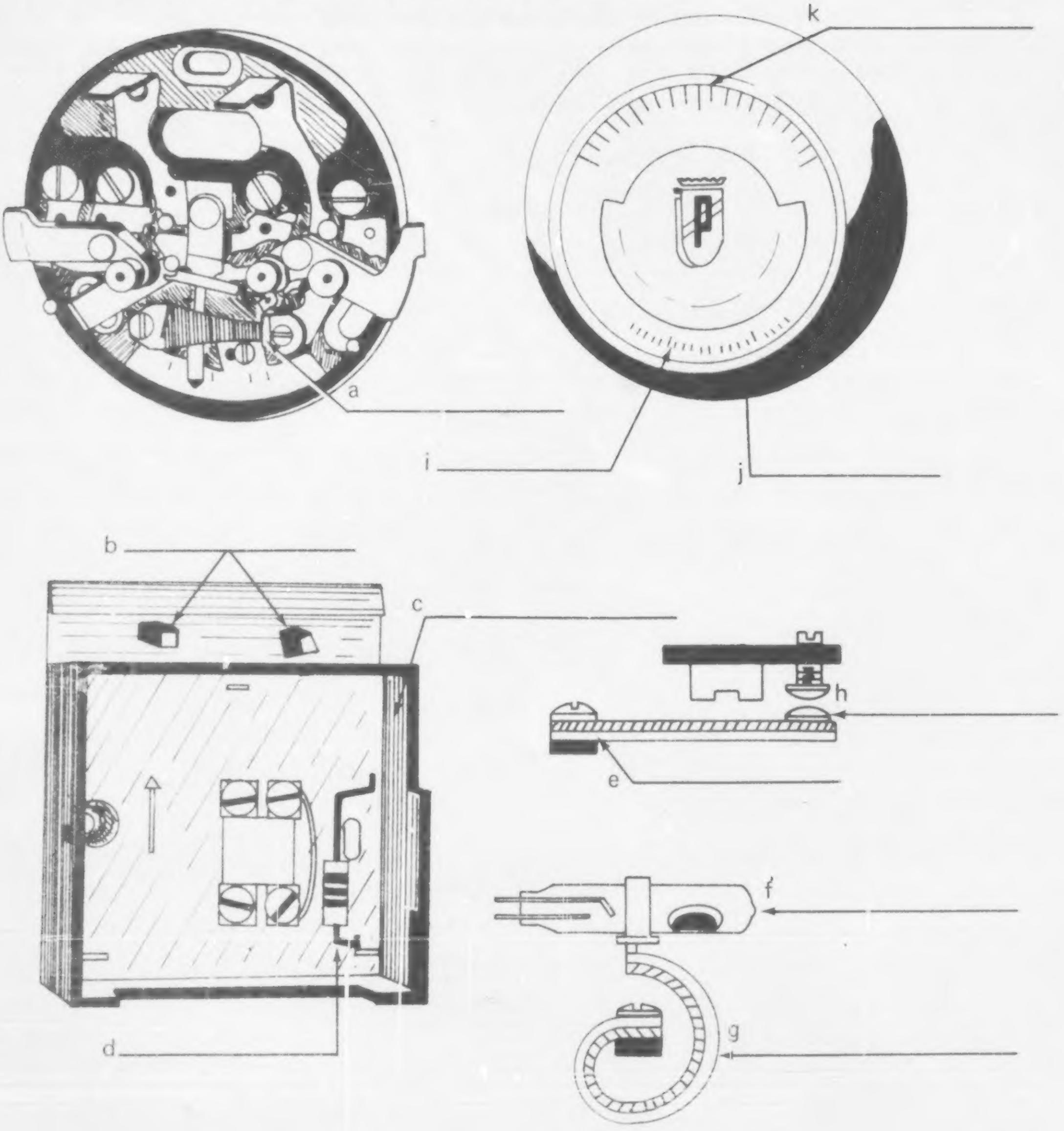
   b.

   c.

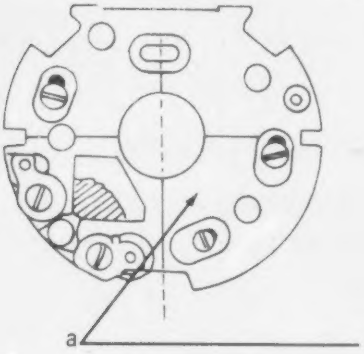
      1)

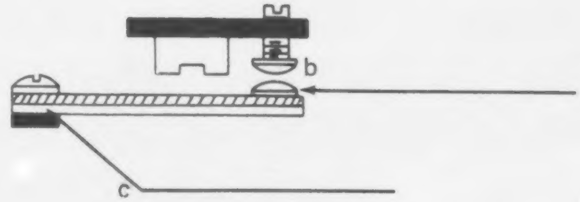
      2)

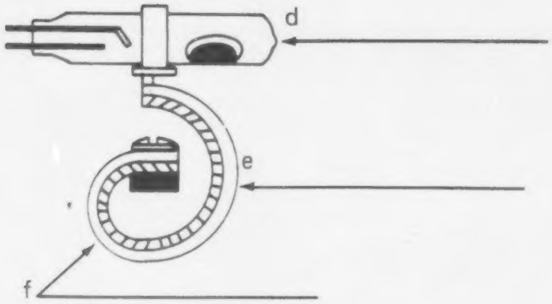
3. Identify the parts of a low voltage thermostat.

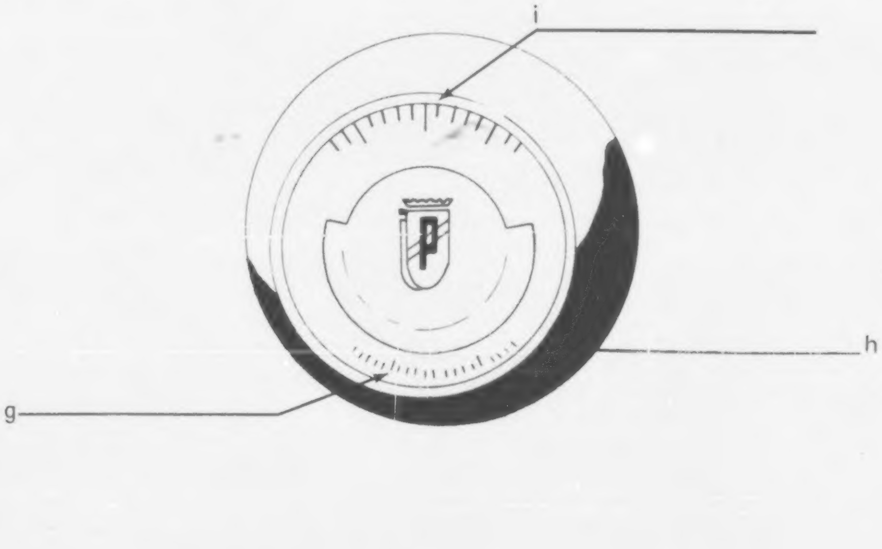

k
a
i
j
b
c
h
e
f
g
d

4. Identify the parts of a millivolt thermostat.

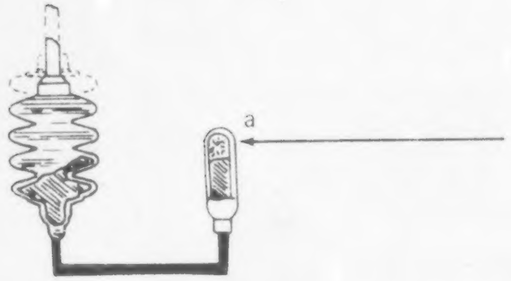


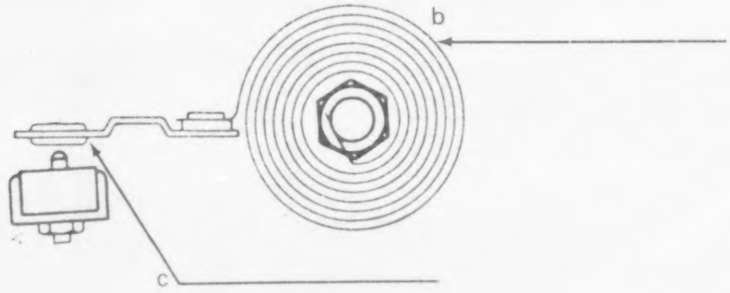


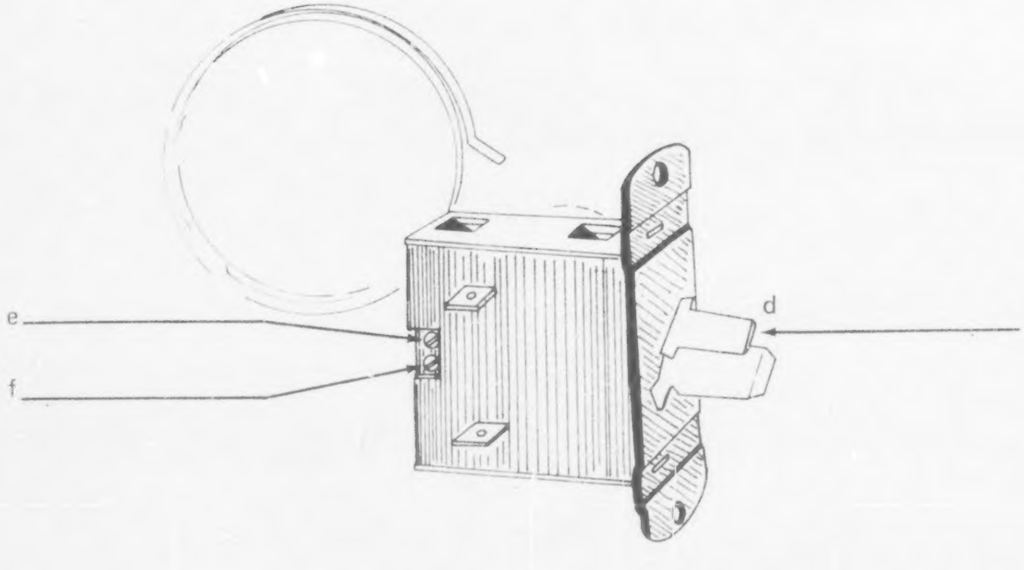




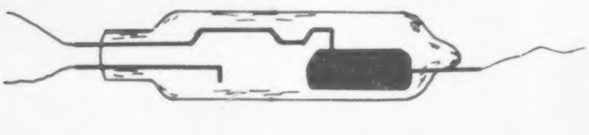
5. Identify the parts of a line voltage thermostat.

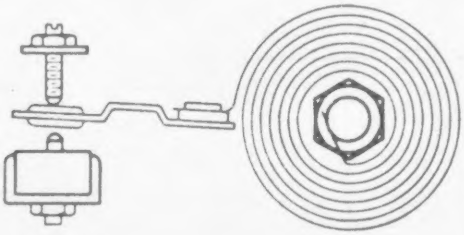




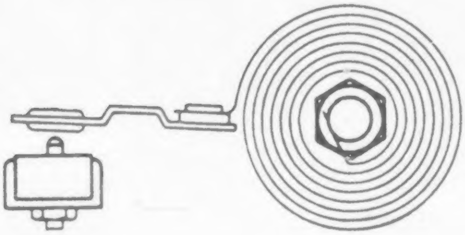


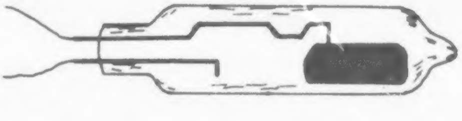
6. Identify the following thermostat contacts by name and switching action.





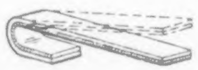
a. ______________________   b. ______________________

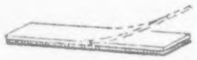




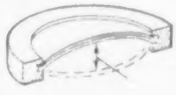
c. ______________________   d. ______________________

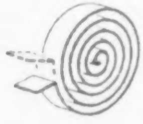
7. Identify the following shapes of thermostatic bimetals.



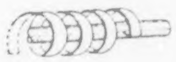


a. ______________________   c. ______________________





b. ______________________   d. ______________________



e. ______________________

8. Discuss the operation of a thermostatic bimetal.

9. Discuss thermostat anticipation.

   a. Heating

   b. Cooling

10. Discuss the characteristics of a two-stage thermostat.

    a. Cooling

    b. Heating

c. Combinations

11. Discuss the advantages of time controlled thermostats.

12. Select guidelines for correctly installing a room thermostat by placing an "X" in the appropriate blanks.

______a. May be mounted on any wall

______b. Locate in conditioned area

______c. Locate 4' above the floor

______d. Must be level

______e. Locate behind a door for protection

______f. Must have normal air circulation

______g. Locate on outside wall 4' 6" to 5' above floor

______h. Keep away from sources of artificial heat or cold

______i. Locate on inside wall approximately 4' 6" to 5' above floor

______j. Seal the wire opening in the wall

13. List the thermostat applications.

a. Low voltage

   1.

   2.

b. Millivolt

   1.

   2.

   3.

c. Line voltage

   1.

   2.

   3.

   4.

   5.

14. Match the low voltage thermostat terminal markings on the left to the proper component. Each component may be used more than once.

_____a. C_1

_____b. V

_____c. G

_____d. H_2

_____e. Rh

_____f. Y_1

_____g. R

_____h. W

_____i. F

_____j. W_2

1. Second stage on two stage heat
2. Fan
3. Power cooling transformer
4. Second stage on two stage cooling
5. Cooling on single stage
6. Power supply
7. Heat on single stage
8. First stage on two stage cooling
9. Power heating transformer
10. First stage on two stage heat

_____k. Rc

_____l. C_2

_____m. H

_____n. C

_____o. Y_2

_____p. W_1

_____q. Y

_____r. H_1

15. Demonstrate the ability to:

a. Wire mercury bulb to correct terminals.

b. Determine heat anticipation.

c. Install a wall thermostat.

(NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

BASIC ELECTRIC THERMOSTATS
UNIT I

ANSWERS TO TEST

1.
    a. 8
    b. 9
    c. 3
    d. 5
    e. 4
    f. 1
    g. 6
    h. 7
    i. 10
    j. 2
    k. 11
2.
    a. Low voltage
    b. Millivolt
    c. Line voltage
        1. Heating or cooling
        2. Refrigeration
3.
    a. Adjustable heat anticipator
    b. Manual switches
    c. Subbase
    d. Cooling anticipator
    e. Bimetal temperature sensing element
    f. Mercury bulb
    g. Bimetal temperature sensing element
    h. Mechanical points
    i. Thermometer
    j. Cover
    k. Manual temperature selector
4.
    a. Subbase
    b. Mechanical points

c. Bimetal temperature sensing element

d. Mercury bulb

e. Bimetal temperature sensing element

f. Heat anticipator

g. Thermometer

h. Cover

i. Manual temperature selector

5. a. Gas/liquid filled bulb temperature sensing element

b. Bimetal temperature sensing element

c. Electrical contacts

d. Range adjustment knob

e. Cut-out

f. Cut-in

6. a. Mercury bulb, single pole double throw

b. Snap action, single pole double throw

c. Snap action, single pole single throw

d. Mercury bulb, single pole single throw

7. a. "U" shaped

b. Snap-disc

c. Cantilever

d. Spiral

e. Helix

8. Discussion should include:

a. Two different metals bonded together

1) Brass--Expands rapidly

2) Invar--Expands slowly

b. Warps when heated or cooled due to different rates of expansion

c. Warping action causes opening or closing of thermostat contacts

9. Discussion should include:

a. Heating

1) Thermostats with bimetal sensing elements

2) In series with thermostat contacts

3) Two types

a) Fixed--Carbon resistor

b) Adjustable--Variable resistor

4) Setting determined by current draw of load

a) Gas valve solenoid

b) Electric heater contactor

b. Cooling

1) Generally low voltage wall thermostats

2) Carbon resistors

3) Resistance of anticipator is determined by the current draw of the contactor coil

4) Parallel to thermostat contacts

10. Discussion should include:

a. Cooling

1) Controls two cooling capacities

2) Two switches on one bimetal, usually mercury bulbs

3) Two degree differential between switches

4) First stage closes at approximately 2°F above the "set" temperature

5) If temperature continues to rise second stage will close at approximately 4°F above "set" temperature

6) Both switches will be open at "set" temperature

b. Heating

   1) Used for the following heating situations:

      a) Gas heating with dual gas valves

      b) Electric furnaces with extra strips

      c) Heat pumps with electric strips for supplementary heat

   2) Two switches on one bimetal, usually mercury bulbs

   3) Two degree differential between switches

   4) First stage closes at approximately 2°F below the "set" temperature

   5) If temperature continues to drop second stage will close at approximately 4°F below "set" temperature

   6) Both switches will be open at set temperature

c. Combinations

   1) Two-stage cooling and single-stage heat

   2) Two-stage heat and single-stage cooling

11. Discussion should include:

   a. Automatically lowers temperature at night

      1) Provides more comfortable sleeping

      2) Conserves energy

         a) Summer by lowering temperature at night when equipment runs more efficiently

         b) Winter by reducing the on time of heating equipment

   b. Automatically increases temperature during the day

   c. Convenient in winter because the increase in temperature occurs early before the occupant arises

12. b, d, f, h, i, j

13. a. Low voltage

      1) Central heating systems

      2) Central cooling systems

b. Millivolt
    1) Wall heaters
    2) Floor furnaces
    3) Central heaters
c. Line voltage
    1) Window air conditioners
    2) Domestic refrigeration
    3) Commercial refrigeration
    4) Industrial air conditioners
    5) Ventilators

14. a. 8
b. 6
c. 2
d. 1
e. 9
f. 8
g. 6
h. 7
i. 2
j. 1
k. 3
l. 4
m. 7
n. 5
o. 4
p. 10
q. 5
r. 10

15. Performance skills evaluated to the satisfaction of the instructor

RELAYS
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify and discuss different types of relays, draw connecting wiring, and check wiring and relays with electrical test instruments. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with relays to the correct definitions.
2. Identify motor starting relays.
3. Identify control relay switching symbols.
4. Match the components to the correct relay terminal markings.
5. List the selection specifications of motor relays.
6. List the six specifications of a contactor.
7. Discuss the characteristics and types of time delay relays.
8. Draw the connecting wiring of a hot wire relay.
9. Draw the connecting wiring of a current relay (coil type).
10. Draw the connecting wiring of a potential relay.
11. Draw the connecting wiring of a fan relay.
12. Draw the connecting wiring of a contactor.
13. Demonstrate the ability to:
    - a. Wire a current relay (hot wire).
    - b. Wire a current relay (coil type).
    - c. Wire a potential relay.
    - d. Wire a fan relay.

e. Check relays with an ohmmeter.

f. Check relays with a voltmeter.

g. Check relays with an ammeter.

RELAYS
UNIT II

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate and discuss the procedures outlined in the job sheets.

   G. Draw a complete relay wiring diagram on chalkboard.

   H. Demonstrate checking relays with electrical test instruments.

   I. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Complete job sheets.

   D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM 1--Motor Starting Relays

      2. TM 2--Contactor

3. TM 3--Time Delay Relays
4. TM 4--Wiring for a Hot Wire Relay
5. TM 5--Wiring for a Current Relay (Coil Type)
6. TM 6--Wiring for a Potential Relay
7. TM 7--Wiring for a Fan Relay
8. TM 8--Wiring for a Contactor

D. Job sheets

1. Job Sheet #1--Wire a Current Relay (Hot Wire)
2. Job Sheet #2--Wire a Current Relay (Coil Type)
3. Job Sheet #3--Wire a Potential Relay
4. Job Sheet #4--Wire a Fan Relay
5. Job Sheet #5--Check Relays With an Ohmmeter
6. Job Sheet #6--Check Relays With a Voltmeter
7. Job Sheet #7--Check Relays With an Ammeter

E. Test

F. Answers to test

II. References:

A. Langley, B. C. *Electric Controls for Refrigeration and Air Conditioning.* Englewood Cliffs, New Jersey: Prentice-Hall Inc., 1974.

B. Althouse, Andrew D.; Turnquist, Carl H.; and Bracciano, Alfred F. *Modern Refrigeration and Air Conditioning.* Homewood, Illinois: Goodheart-Willcox Co., 1975.

RELAYS
UNIT II

INFORMATION SHEET

I. Terms and definitions

   A. Relay--Electromagnetic switch

   B. Time delay relay--Provides a predetermined interval between operations of a device

   C. Contactor--Magnetic relay switch which usually opens and closes a line voltage circuit, actuated by a control circuit magnetic coil

   D. Potential relay--Motor starting relay that operates off of the back EMF generated in the start winding; used primarily on 1/2 h.p. or larger motors

   E. Current relay (coil type)--Motor starting relay that disengages the start winding after the compressor motor reaches 75% of its rated speed; used on fractional horsepower motors

   F. Current relay (hot wire type)--Motor starting relay that disengages the start winding by the movement of a thermal wire; used on small fractional horsepower motors

   G. Control relay--Electromagnetic switch that controls a line voltage load by means of control voltage

   H. Pilot duty--An electrical rating applied to devices used to energize and de-energize pilot (control) circuits

II. Motor starting relays (Transparency 1)

   A. Voltage relay (potential)

   B. Current relay

      1. Coil

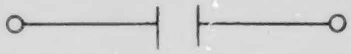
      2. Hot wire

   C. Solid state relay

III. Control relay switching symbols

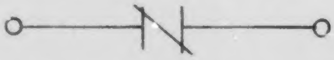
   (NOTE: Control relays are available with many variations of switches. The common switching arrangements are given below.)

   A. Single pole single throw, normally open (SPST, N.O.)

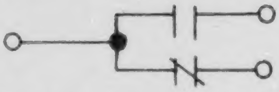


INFORMATION SHEET

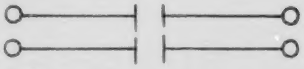
B. Single pole single throw, normally closed (SPST, N.C.)



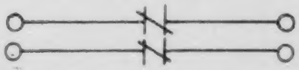
C. Single pole double throw (SPDT)



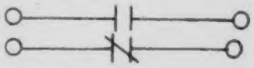
D. Double pole single throw, normally open (DPST, N.O.)



E. Double pole single throw, normally closed (DPST, N.C.)



F. Double pole single throw, normally closed and normally open (DPST, N.C. and N.O.)



(NOTE: Circuit diagrams will always show a relay in the de-energized position.)

IV. Relay terminal markings

A. Current relays and solid state

(NOTE: Current relays include both hot-wire and coil type.)

1. Terminal "L" connects to line voltage

2. Terminal "M" connects to motor run winding

   (NOTE: Some relay manufacturers may mark this terminal with an "R".)

3. Terminal "S" connects to motor start winding

   (NOTE: Some relay manufacturers mark this terminal with a "P" for phase winding and others mark it with an "A" for auxiliary winding.)

4. Terminals #1 and #2 are points for wire connections

   (NOTE: These terminals are not connected to the internal working components of the relay.)

INFORMATION SHEET

B. Voltage relays (potential)

(NOTE: Solid state relays used for this application have two unmarked terminals which connect to the run capacitor terminals.)

1. Terminal #1 connects to start capacitor
2. Terminal #2 connects to motor start winding
3. Terminal #5 connects to motor common terminal
4. Terminals #3, #4, and #6 are points for wire connections

   (NOTE: These terminals are not connected to the internal working components of the relay.)

(NOTE: Control relays such as fan relays have their terminal markings identified on the side of the relay.)

(CAUTION: Do not connect line voltage leads onto the low voltage coil terminals of a control relay because this would ruin the relay.)

V. Selection specifications of motor relays

A. Current relay (coil type)

1. Original relay part number
2. Compressor motor model number
3. Compressor motor horsepower
4. Voltage
5. Positional
6. Equipment model and serial number

B. Current relay (hot wire type)

1. Original relay part number
2. Compressor motor horsepower
3. Compressor motor amperage
4. Voltage
5. Equipment model and serial number

INFORMATION SHEET

C. Voltage relay (potential)

1. Original relay part number
2. Compressor motor horsepower
3. Line voltage
4. Constant coil voltage

   (NOTE: The constant coil voltage is the back EMF generated in the compressor motor start winding.)

5. Pick-up voltage
6. Dropout voltage

D. Solid state relay

1. One size replaces all current relays on 1/12 thru 1/2 horsepower compressor motors
2. One size replaces all hard start kits on 1/2 thru 5 horsepower permanent split capacitor compressor motors
3. Nonpositional
4. Line voltage

   (NOTE: This type of relay is not recommended for use on nonequalized systems.)

E. Control relay

1. Original relay part number
2. Coil voltage
3. Full load amperage of load being controlled
4. Locked rotor amperage of load being controlled
5. Switch arrangements
6. Load horsepower

INFORMATION SHEET

VI. Specifications of contactors (Transparency 2)

- A. Original contactor part number
- B. Full load amperage of load
- C. Locked rotor amperage of load
- D. Number and positions of poles
- E. Coil voltage
- F. Dimensions of contactor

VII. Time delay relays (Transparency 3)

- A. Characteristics
  - 1. Delays or sequences the energizing of loads

    Example: This type of relay is commonly used for electric heating to prevent the total load from coming on at one time

  - 2. Pilot voltage controlled
  - 3. Line voltage contacts

    (NOTE: Some relays will have low voltage contacts in addition to line voltage contacts. Do not get the two sets of contacts confused.)

- B. Types
  - 1. Thermal warp switch
  - 2. Magnetic coil and lever in an oil filled cavity
  - 3. Motorized with cam actuated contacts

VIII. Connecting wiring of a hot wire relay (Transparency 4)

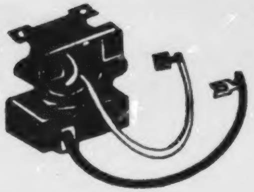
IX. Connecting wiring of a current relay (coil type) (Transparency 5)

X. Connecting wiring of a potential relay (Transparency 6)

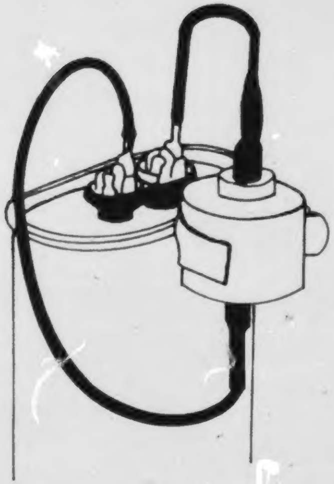
XI. Connecting wiring of a fan relay (Transparency 7)

XII. Connecting wiring of a contactor (Transparency 8)

Motor Starting Relays

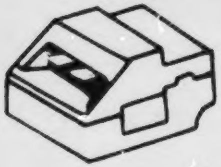


Current Relay (Coil Type)

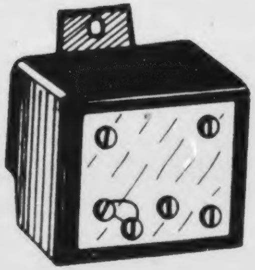


Solid-State Relay

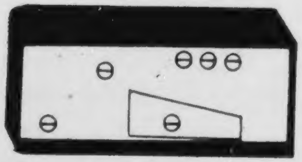
For PSC Compressor



Solid-State Relay

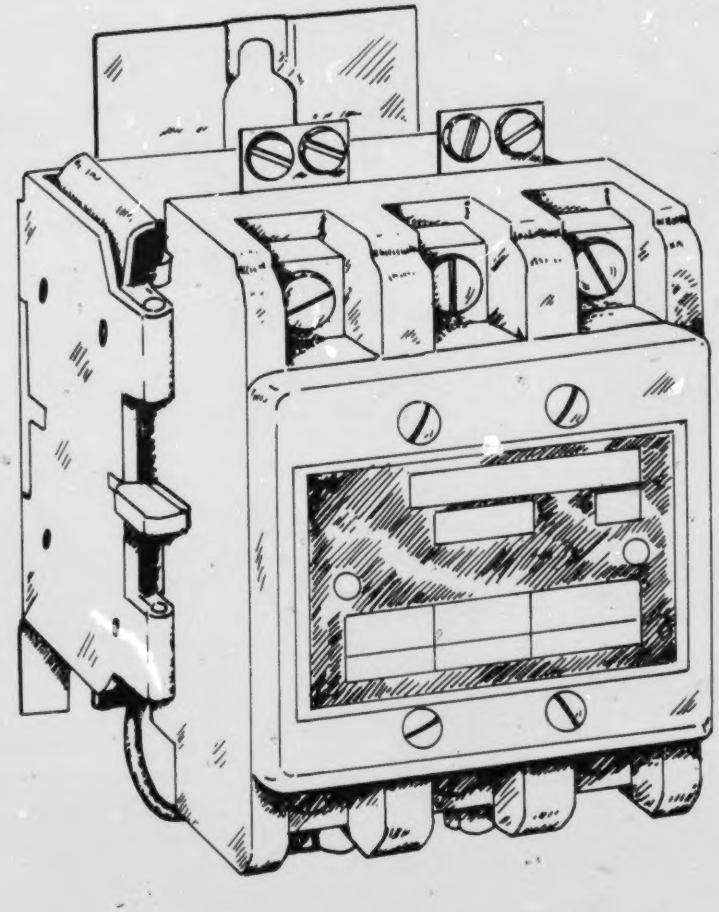


Voltage Relay (Potential)

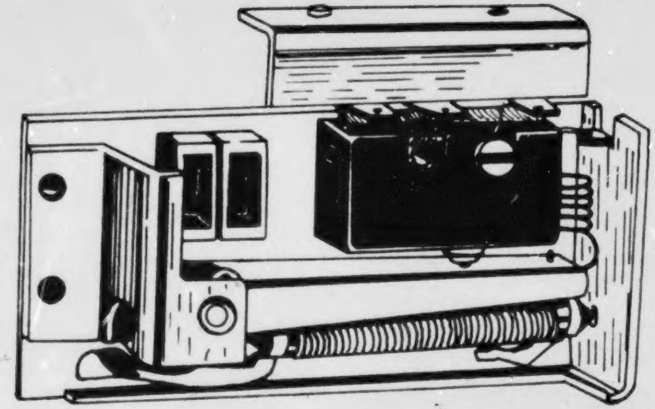


Current Relay (Hot Wire)

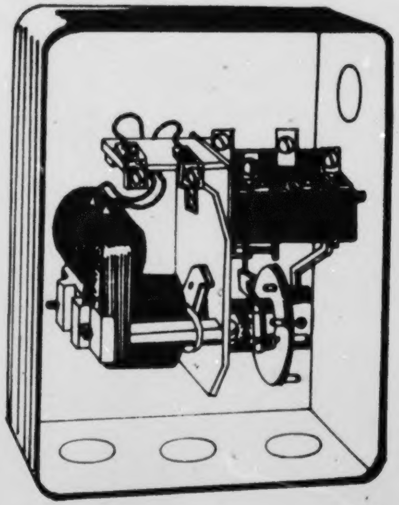
Contactor



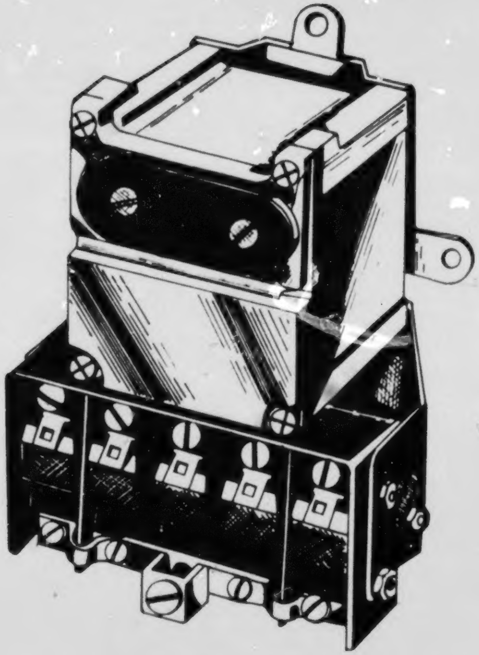
Time Delay Relays



Thermal Switch

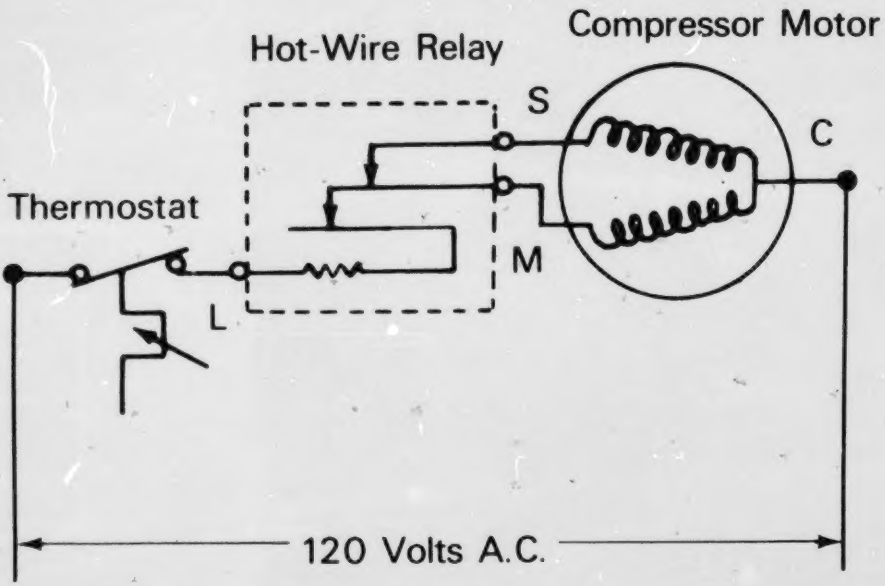


Motorized

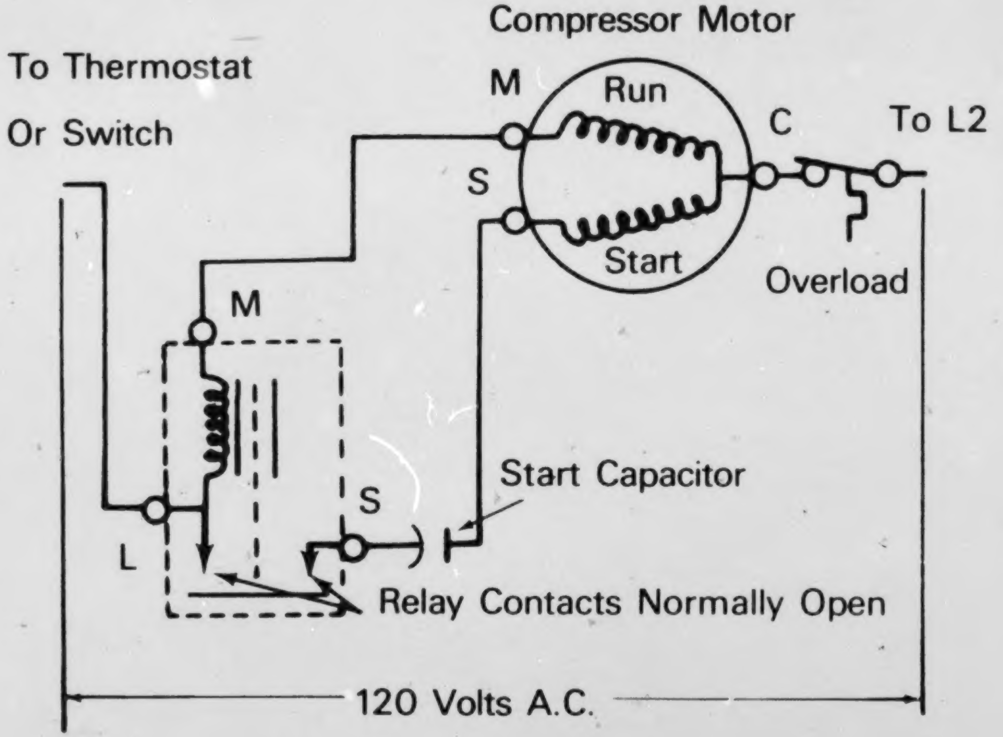


Oil Filled

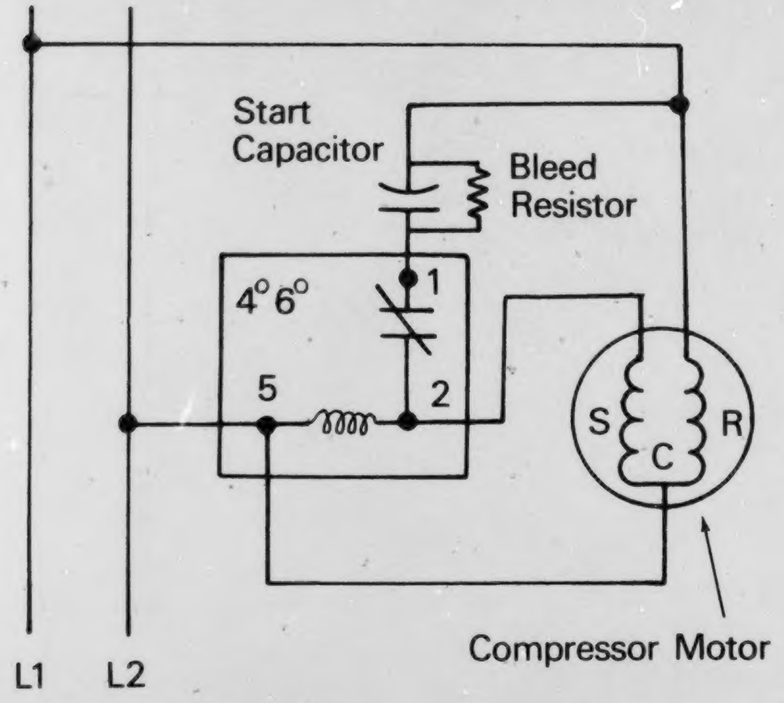
Wiring For A Hot Wire Relay


Compressor Motor
Hot-Wire Relay
S
C
Thermostat
M
L
120 Volts A.C.

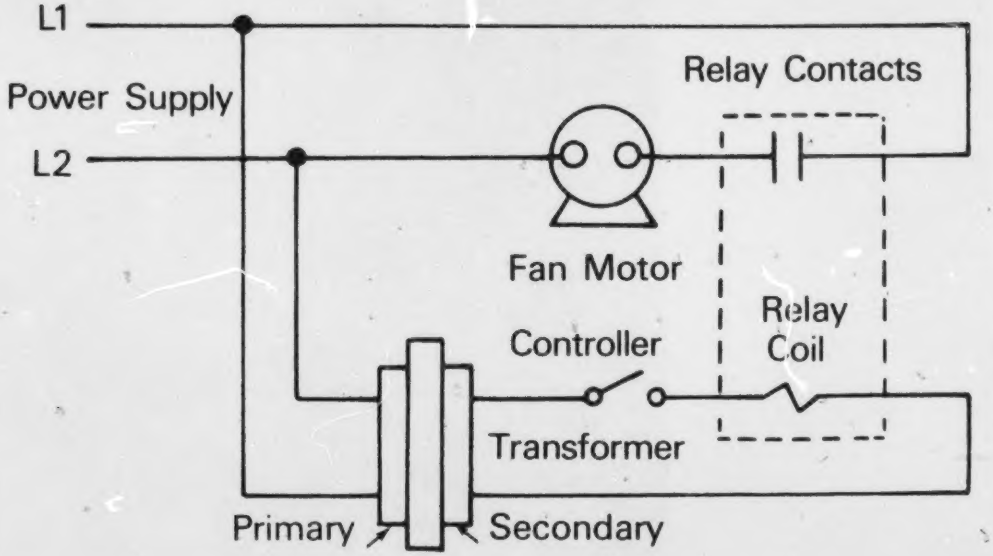
Wiring For A Current Relay (Coil Type)


Compressor Motor
To Thermostat
Or Switch
M
Run
C
To L2
S
Start
Overload
M
S
Start Capacitor
L
Relay Contacts Normally Open
120 Volts A.C.

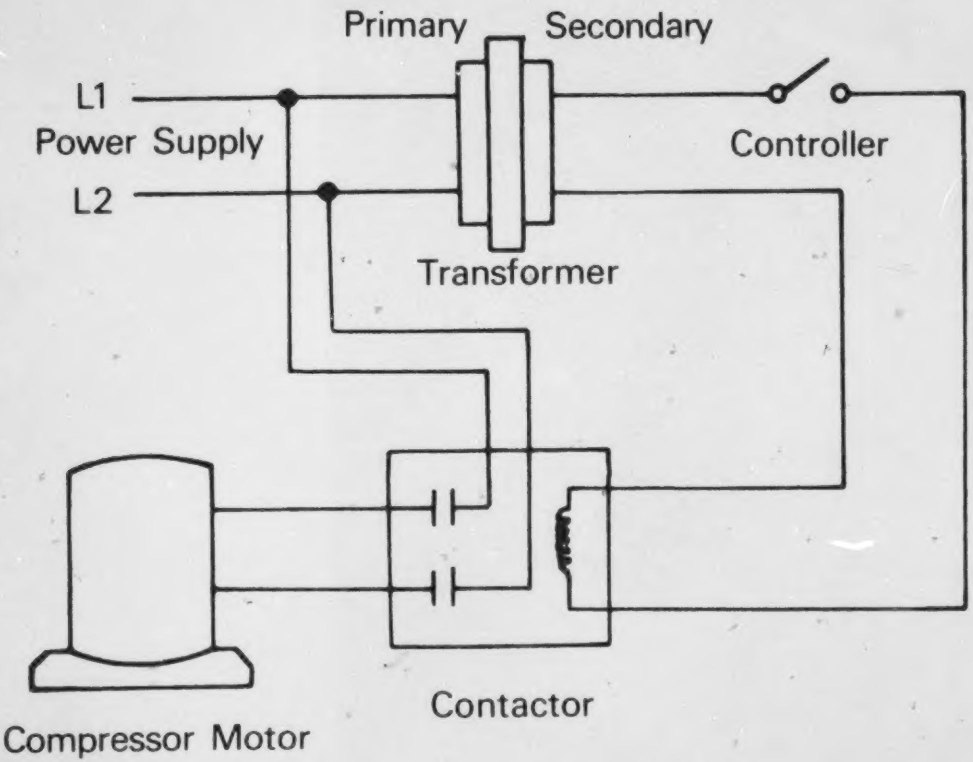
Wiring For A Potential Relay


Start
Capacitor
Bleed
Resistor
4° 6°
1
5
2
S
R
C
Compressor Motor
L1
L2

Wiring For A Fan Relay


L1
Power Supply
L2
Relay Contacts
Fan Motor
Relay Coil
Controller
Transformer
Primary
Secondary

Wiring For A Contactor


Primary
Secondary
L1
Power Supply
L2
Controller
Transformer
Compressor Motor
Contactor

ACR II - 73-B

RELAYS
UNIT II

JOB SHEET #1--WIRE A CURRENT RELAY (HOT WIRE)

I. Tools and materials

   A. Screwdriver (standard slot)

   B. Screw starter

   C. Needle nose pliers

   D. Hot wire relay

   E. Refrigeration system

II. Procedure

   A. Check to be sure the electrical power is disconnected from system

   (CAUTION: Discharge start capacitor with a bleed resistor if the starting circuit has one.)

   B. Check horsepower and voltage rating of compressor motor

   C. Check relay to be sure that it is the proper size for the compressor motor

   D. Remove existing relay and wires from compressor motor terminals

   E. Mark each wire as to its point of connection as it is removed

   (NOTE: When you are changing an electrical component, it is always a good idea to identify the location of each wire as it is removed.)

   F. Connect line voltage wire to "L" on the relay

   (NOTE: The temperature control should be in the line wire. Refer to transparency for a wiring diagram.)

   G. Connect a wire from "S" on the relay to the start terminal on the compressor motor

   (NOTE: If the system requires a start capacitor it must go in series between "S" on the relay and the compressor motor start terminal.)

   H. Connect a wire from "M" on the relay to the run terminal on the compressor motor

JOB SHEET #1

I. Connect the other side of the line voltage wire to the compressor motor common terminal

(NOTE: An external overload is not used with a hot wire relay.)

J. Have instructor inspect

K. Connect electrical power

L. Close temperature control

(CAUTION: If the compressor motor does not start or if it short cycles, disconnect the power and recheck procedure.)

M. Clean up and put away tools

RELAYS
UNIT II

JOB SHEET #2--WIRE A CURRENT RELAY (COIL TYPE)

I. Tools and materials

A. Screwdriver (standard slot)

B. Screw starter

C. Needle nose pliers

D. Current relay

E. Refrigeration system

II. Procedure

A. Check to be sure the electrical power is disconnected from system

(CAUTION: Discharge start capacitor with a bleed resistor if the starting circuit has one.)

B. Check horsepower and voltage rating of compressor motor

C. Check relay to be sure that it is the proper size for the compressor motor

D. Remove existing relay and wires from compressor motor terminals

E. Mark each wire as to its point of connection as it is removed

(NOTE: When you are changing an electrical component, it is always a good idea to identify the location of each wire as it is removed.)

F. Connect line voltage wire to "L" on the relay

(NOTE: The temperature control would be in this electrical line wire. Refer to transparency for a wiring diagram.)

G. Connect a wire from "S" on the relay to the start terminal on the compressor motor

(NOTE: If the system requires a start capacitor, it must go in series between "S" on the relay and the compressor motor start terminal.)

H. Connect a wire from "M" on the relay to the run terminal on the compressor motor

JOB SHEET #2

I. Connect the other side of the line to the compressor motor external overload

J. Mount the relay in the proper position

(NOTE: Coil type current relays must be mounted in the proper position to prevent the start contacts from remaining closed.)

K. Have instructor inspect

L. Connect electrical power

M. Close temperature control

(CAUTION: If the compressor motor does not start or if it short cycles, disconnect the power and recheck procedure.)

N. Clean up and put away tools

RELAYS
UNIT II

JOB SHEET #3--WIRE A POTENTIAL RELAY

I. Tools and materials

A. Screwdriver (standard slot)

B. Screw starter

C. Needle nose pliers

D. Potential relay

E. Refrigeration system

F. Start capacitor

II. Procedure

A. Check to be sure the electrical power is disconnected

B. Check horsepower and voltage rating of compressor motor

C. Check relay to be sure that it is the proper size for the compressor motor

D. Remove existing relay and wires from compressor motor terminals

E. Mark each wire as to its point of connection as it is removed

(NOTE: When you are changing an electrical component, it is always a good idea to identify the location of each wire as it is removed.)

F. Connect one side of line voltage to one of the start capacitor terminals

G. Connect a wire from the remaining start capacitor terminal to #1 on the potential relay

(NOTE: The start capacitor should be equipped with a bleed resistor.)

H. Connect a wire from #2 on the relay to the start terminal on the compressor motor

I. Connect a wire from #5 on the relay to the common terminal on the compressor motor

JOB SHEET #3

(NOTE: This wire may connect to one side of an external overload depending on the system used. Check with the instructor if in doubt.)

J. Have instructor inspect

K. Connect electrical power

L. Close temperature control

(CAUTION: If the compressor motor does not start or if it short cycles, disconnect the power and recheck procedure.)

M. Clean up and put away tools

RELAYS
UNIT II

JOB SHEET #4--WIRE A FAN RELAY

I. Tools and materials

   A. Screwdriver (standard slot)

   B. Screw starter

   C. Needle nose pliers

   D. Fan relay

   E. Blower unit with 24 V.A.C. control

II. Procedure

   A. Check to be sure the electrical power is disconnected

   B. Locate the "hot" wire going to the fan motor

   (NOTE: This would be the wire that is connected to the black wire from the power supply.)

   C. Place the line voltage contacts of the relay in series with the "hot" wire

   (CAUTION: Check the relay and be sure which terminals are for line voltage and which are for low voltage before connecting any wires.)

   D. Connect a wire from one side of the relay coil to the secondary common of the 24 V.A.C. transformer

   E. Connect the other side of the relay coil to a control switch

   (NOTE: If this is a central heating and cooling system, the relay coil would probably connect to a green wire from "G" or "F" on the thermostat subbase.)

   F. Have instructor inspect

   G. Connect electrical power

   H. Close the control switch

   (NOTE: If the fan motor does not start, disconnect the electrical power and recheck the procedure.)

   I. Clean up and put away tools

RELAYS
UNIT II

JOB SHEET #5--CHECK RELAYS WITH AN OHMMETER

I. Tools and materials

A. Current relay (coil type)

B. Potential relay

C. Ohmmeter

II. Procedure

(NOTE: This procedure will not work to check a nonpositional relay.)

A. Zero ohmmeter in R x 1 scale

(NOTE: All electrical power must be disconnected from the system and all wires disconnected from a relay when checking it with an ohmmeter.)

B. Place ohmmeter leads on "L" and "M" terminals of the current relay

C. Hold relay in upright position

D. Read ohmmeter scale

(NOTE: If the ohmmeter reads approximately one ohm, the relay coil is okay, but if it reads infinity, the relay coil is open.)

E. Move ohmmeter lead from "L" to "S" on relay

(NOTE: If the ohmmeter reads infinity, the relay contacts are open as they should be, but if it has a low resistance reading, the contacts are stuck closed.)

F. Turn relay upside down

G. Place ohmmeter leads on "M" and "S" terminals

(NOTE: If the ohmmeter has a low resistance reading, the contacts are okay, but if the reading is infinity or high resistance, contacts are not closing properly.)

H. Place ohmmeter leads on terminals #1 and #2 of the potential relay

(NOTE: If the ohmmeter reads infinity or high resistance, this indicates defective relay contacts, but if there is a zero ohm reading, this indicates good contacts.)

JOB SHEET #5

I. Move ohmmeter lead from terminal #1 to #5

J. Read the ohmmeter

(NOTE: The resistance of the coil of a potential relay is high around 800 ohms due to the many turns of fine wire.)

K. Have the instructor check your work

L. Clean up and put away tools and materials

RELAYS
UNIT II

JOB SHEET #6--CHECK RELAYS WITH A VOLTMETER

I. Tools and materials

  A. Current relays

  B. Potential relay

  C. Voltmeter

  D. Refrigeration systems

II. Procedure

  A. Place voltmeter function switch in the highest AC range

  B. Place voltmeter leads on the "L" and "S" terminals of a current relay

  C. Turn on refrigeration system

  D. Read voltmeter

  E. Select lower voltmeter scale if the meter does not read in center one-third of scale

  (NOTE: Voltage reading should only be momentary then drop to zero. If voltage reading exists for longer than ten seconds, disconnect electric power and check for stuck relay contacts.)

  F. Place voltmeter function switch in the highest AC range

  G. Place voltmeter leads on the #1 and #2 terminals of potential relay

  H. Read voltmeter momentarily after start-up

  (NOTE: At the instant of start the voltmeter will read zero, but as soon as the compressor motor reaches approximately 75% of its running speed, the contacts should open and the voltmeter will read line voltage.)

  I. Place the voltmeter leads on the #2 and #5 terminals of the potential relay

  J. Read the back EMF and record

  K. Have the instructor check

  L. Disconnect electric power from refrigeration system

  M. Clean up and put away meters

RELAYS
UNIT II

JOB SHEET #7--CHECK RELAYS WITH AN AMMETER

I. Tools and materials

   A. Current relays

   B. Potential relay

   C. Ammeter (clamp on type)

   D. Refrigeration systems

II. Procedure

   A. Place ammeter in highest scale

   B. Clamp ammeter around the wire from the "S" terminal on a current relay

   C. Connect electricity to refrigeration system

   D. Turn on refrigeration system

   E. Read amperage draw

   (NOTE: Amperage draw should only be momentary then drop to zero. If the amperage draw does not drop to zero after about ten seconds, disconnect electricity and check the relay for stuck contacts.)

   F. Clamp ammeter around the wire from the "M" terminal on a current relay

   (NOTE: The refrigeration system should be running.)

   G. Select ammeter scale that will give a center scale reading

   H. Check refrigeration systems data plate to obtain F.L.A.

   I. Compare the rated F.L.A. to the ammeter reading

   J. Have instructor check

   K. Place ammeter in highest scale

   L. Clamp ammeter aound the wire from terminal #2 on a potential relay

   M. Start refrigeration system

JOB SHEET #7

N. Read amperage draw

(NOTE: Amperage draw should only be momentary then drop off. There may be a slight amperage draw due to the back EMF.)

O. Have instructor check

P. Stop refrigeration system

Q. Disconnect electricity

R. Clean up and put away tools

RELAYS
UNIT II

NAME______________________________

TEST

1. Match the terms on the right to the correct definitions.

______a. Motor starting relay that disengages the start winding after the compressor motor reaches 75% of its rated speed; used on fractional horsepower motors

______b. Electromagnetic switch that controls a line voltage load by means of control voltage

______c. Provides a predetermined interval between operations of a device

______d. Motor starting relay that operates off of the back EMF generated in the start winding; used primarily on 1/2 h.p. or larger motors

______e. Electromagnetic switch

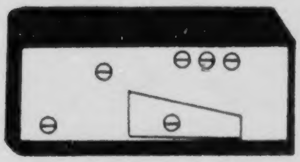
______f. Motor starting relay that disengages the start winding by the movement of a thermal wire; used on small fractional horsepower motors

______g. Magnetic relay switch which usually opens and closes a line voltage circuit, actuated by a control circuit magnetic coil

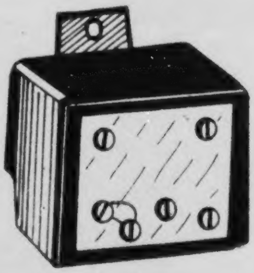
______h. An electrical rating applied to devices used to energize and de-energize pilot (control) circuits

1. Potential relay
2. Control relay
3. Relay
4. Current relay (coil type)
5. Pilot duty
6. Contactor
7. Current relay (hot wire type)
8. Time delay relay

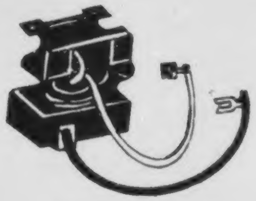
2. Identify the motor starting relays.



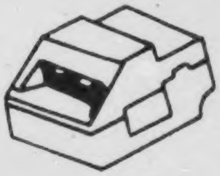
a. ______________________



b. ______________________

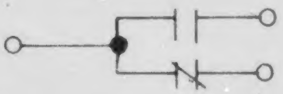


c. ______________________

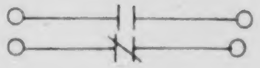


d. ______________________

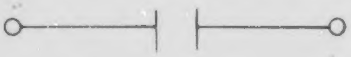
3. Identify the control relay switching symbols.



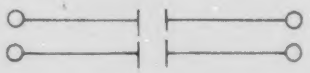
a. ______________________



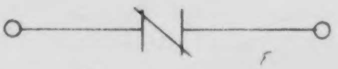
b. ______________________



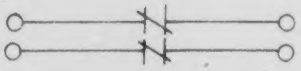
c. ______________________



d. ______________________



e. ______________________



f. ______________________

4. Match the components on the right to the correct relay terminal markings.

______a. #1 voltage relay

______b. "L" current or solid state relay

______c. #2 current relay

______d. "M" current or solid state relay

______e. #5 voltage relay

______f. #6 voltage relay

______g. "S" current or solid state relay

______h. #2 voltage relay

1. Motor start winding
2. Line voltage
3. Wire connections
4. Motor run winding
5. Motor common terminal
6. Start capacitor

5. List the selection specifications of motor relays.

   a. Current relay (coil type)

      1)

      2)

      3)

      4)

      5)

      6)

   b. Current relay (hot wire type)

      1)

      2)

      3)

      4)

      5)

   c. Voltage relay (potential)

      1)

      2)

      3)

      4)

      5)

      6)

   d. Solid state relay

      1)

      2)

      3)

      4)

e. Control relay

1)

2)

3)

4)

5)

6. List the six specifications of a contactor.

a.

b.

c.

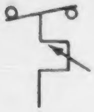
d.

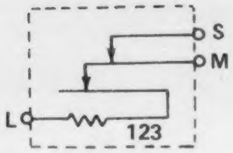
e.

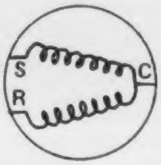
f.

7. Discuss the characteristics and types of time delay relays.

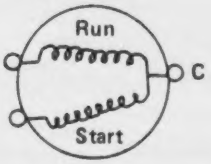
8. Draw the connecting wiring of a hot wire relay.

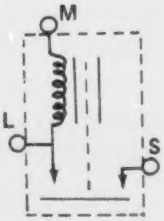


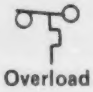




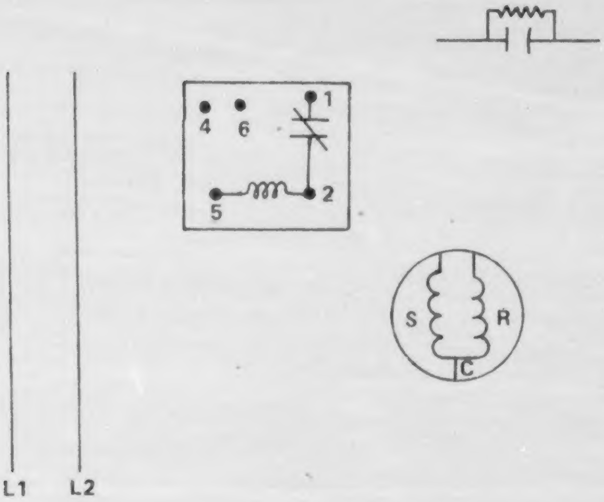
9. Draw the connecting wiring of a current relay (coil type).



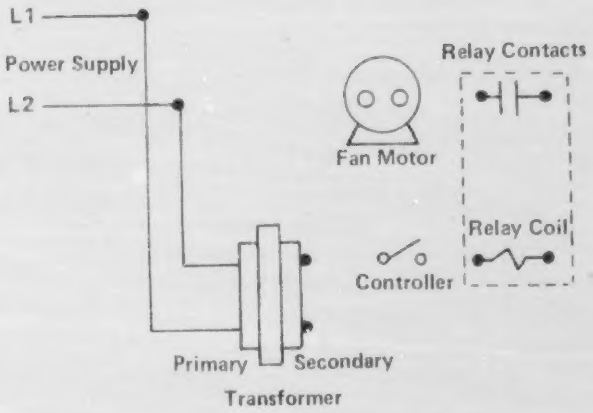




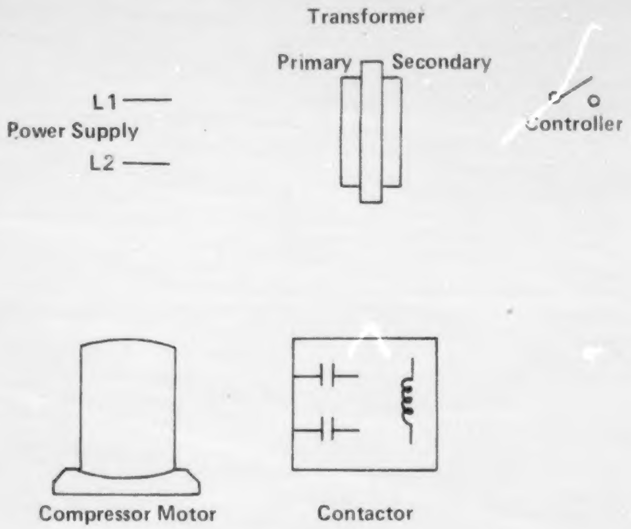
10. Draw the connecting wiring of a potential relay.


4
6
1
2
5
S
R
C
L1
L2

11. Draw the connecting wiring of a fan relay.


L1
Power Supply
L2
Fan Motor
Relay Contacts
Relay Coil
Controller
Primary
Secondary
Transformer

12. Draw the connecting wiring of a contactor.


Transformer
Primary
Secondary
L1
Power Supply
L2
Controller
Compressor Motor
Contactor

13. Demonstrate the ability to:

a. Wire a current relay (hot wire).

b. Wire a current relay (coil type).

c. Wire a potential relay.

d. Wire a fan relay.

e. Check relays with an ohmmeter.

f. Check relays with a voltmeter.

g. Check relays with an ammeter.

(NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

RELAYS
UNIT II

ANSWERS TO TEST

1. a. 4
   b. 2
   c. 8
   d. 1
   e. 3
   f. 7
   g. 6
   h. 5
2. a. Current relay (hot wire type)
   b. Voltage relay (potential)
   c. Current relay (coil type)
   d. Solid state relay
3. a. Single pole double throw (SPDT)
   b. Double pole single throw, normally closed and normally open (DPST, N.C. and N.O.)
   c. Single pole single throw, normally open (SPST, N.O.)
   d. Double pole single throw, normally open (DPST, N.O.)
   e. Single pole single throw, normally closed (SPST, N.C.)
   f. Double pole single throw, normally closed (DPST, N.C.)
4. a. 6
   b. 2
   c. 3
   d. 4
   e. 5
   f. 3
   g. 1
   h. 1
5. a. Current relay (coil type)
      1) Original relay part number
      2) Compressor motor model number
      3) Compressor motor horsepower
      4) Voltage
      5) Positional
      6) Equipment model and serial number

b. Current relay (hot wire type)
    1) Original relay part number
    2) Compressor motor horsepower
    3) Compressor motor amperage
    4) Voltage
    5) Equipment model and serial number

c. Voltage relay (potential)
    1) Original relay part number
    2) Compressor motor horsepower
    3) Line voltage
    4) Constant coil voltage
    5) Pick-up voltage
    6) Dropout voltage

d. Solid state relay
    1) One size replaces all current relays on 1/12 thru 1/2 horsepower compressor motors
    2) One size replaces all hard start kits on 1/2 thru 5 horsepower permanent split capacitor compressor motors
    3) Nonpositional
    4) Line voltage

e. Control relay
    1) Original relay part number
    2) Coil voltage
    3) Full load amperage of load being controlled
    4) Locked rotor amperage of load being controlled
    5) Switch arrangements
    6) Load horsepower

6. a. Original contactor part number
    b. Full load amperage of load
    c. Locked rotor amperage of load

d. Number and positions of poles

e. Coil voltage

f. Dimensions of contactor

7. Discussion should include:

a. Characteristics

1) Delays or sequences the energizing of loads

2) Pilot voltage controlled

3) Line voltage contacts

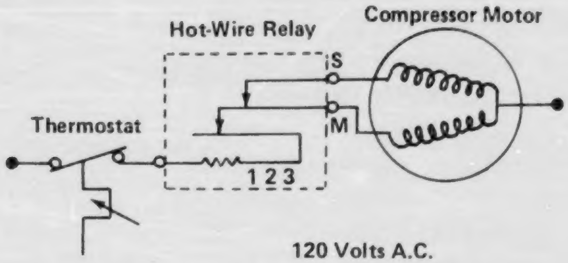
b. Types

1) Thermal warp switch

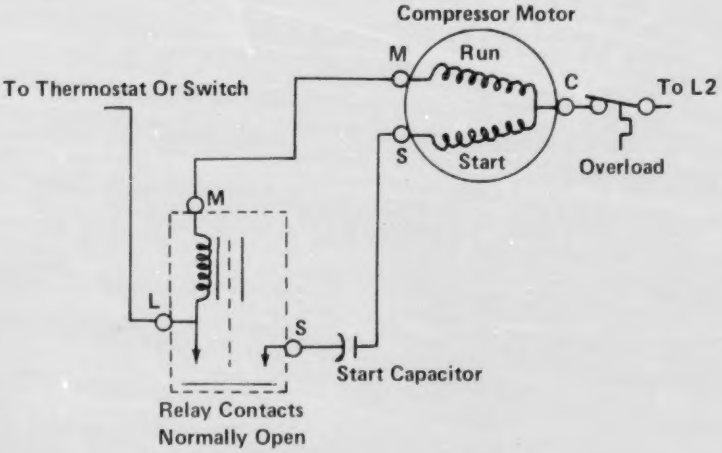
2) Magnetic coil and lever in an oil filled cavity

3) Motorized with cam actuated contacts

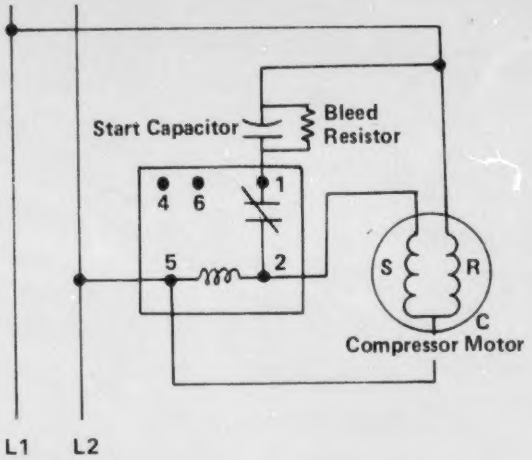
8.


Hot-Wire Relay
Compressor Motor
S
M
Thermostat
1 2 3
120 Volts A.C.

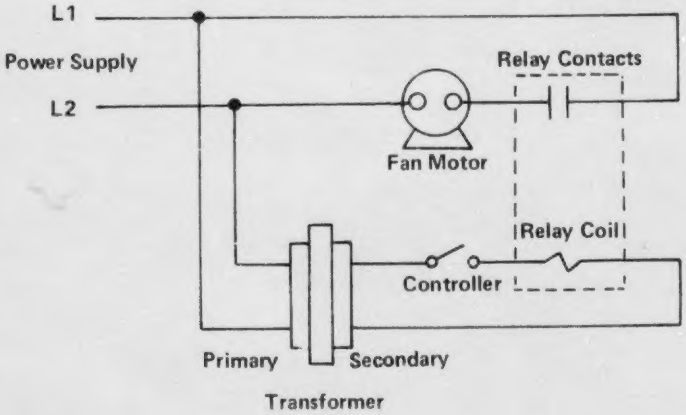
9.


Compressor Motor
M
Run
To Thermostat Or Switch
C
To L2
S
Start
Overload
M
L
S
Start Capacitor
Relay Contacts
Normally Open

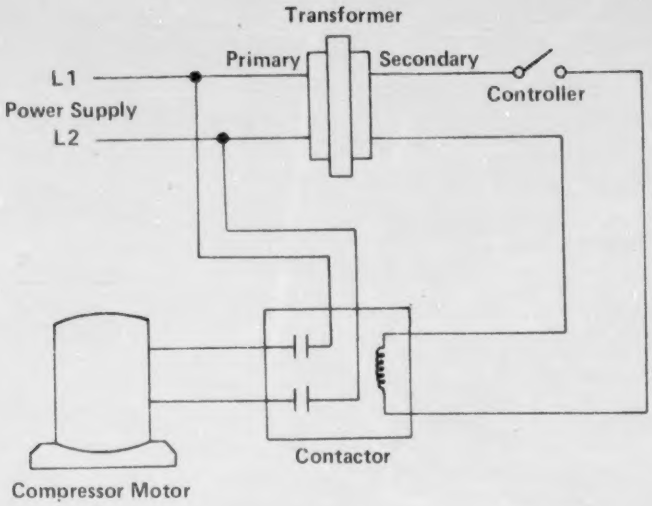
10.


Start Capacitor
Bleed Resistor
4
6
1
5
2
S
R
C
Compressor Motor
L1
L2

11.


L1
Power Supply
L2
Relay Contacts
Fan Motor
Relay Coil
Controller
Primary
Secondary
Transformer

12.


Transformer
Primary
Secondary
L1
Power Supply
L2
Controller
Compressor Motor
Contactor

13. Performance skills evaluated to the satisfaction of the instructor

PROTECTION DEVICES
UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to match terms to the correct definitions, identify common types of protection devices, and discuss their operations. The student should also be able to list national electrical code requirements pertaining to fuses and circuit breakers. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with protection devices to the correct definitions.
2. Identify types of overcurrent protection devices.
3. Describe the operation of a single element fuse.
4. Describe the operation of a time delay fuse.
5. Describe the operation of a circuit breaker.
6. List national electrical code requirements pertaining to fuses that are less than 600v.
7. List four national electrical code requirements pertaining to circuit breakers that are less than 600v.
8. Identify the types of pressure actuated protection devices.
9. Describe the pressure actuated protection devices.
10. Identify the types of electrical system protection devices.
11. Describe the electrical system protection devices.
12. Demonstrate the ability to:
    a. Adjust a high pressure switch.
    b. Adjust a low pressure switch.
    c. Install an oil pressure switch.
    d. Install a lockout relay.
    e. Check a solid-state compressor motor protector.

PROTECTION DEVICES
UNIT III

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate and discuss the procedures outlined in the job sheets.

   G. Discuss use of the national electrical code.

   H. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Complete job sheets.

   D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM 1--Overcurrent Protection Devices

      2. TM 2--How a Fuse Works

      3. TM 3--How a Time Delay Fuse Works

4. TM 4--How a Circuit Breaker Works
5. TM 5--Pressure Actuated Protection Devices
6. TM 6--Oil Pressure Switch Wiring Diagram
7. TM 7--Low Pressure Switch Wiring Diagram
8. TM 8--High Pressure Switch Wiring Diagram
9. TM 9--Dual Pressure Switch Wiring Diagram
10. TM 10--Electrical System Protection Devices
11. TM 11--Lockout Relay Wiring Diagram

D. Job sheets

1. Job Sheet #1--Adjust a High Pressure Switch
2. Job Sheet #2--Adjust a Low Pressure Switch
3. Job Sheet #3--Install an Oil Pressure Switch
4. Job Sheet #4--Install a Lockout Relay
5. Job Sheet #5--Check a Solid-State Compressor Motor Protector

E. Test

F. Answers to test

II. References:

A. *Maintaining the Lighting and Wiring System.* Athens, Georgia: American Association for Vocational Instructional Materials, 1971.

B. *Protection Handbook.* St. Louis, Missouri: Bussman M.F.G. Division/McGraw-Edison Co., 1972.

C. *National Electrical Code.* Boston, Massachusetts: National Fire Protection Association, 1974.

D. Langley, B. C. *Electric Controls for Refrigeration and Air Conditioning.* Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1974.

E. Althouse, Andrew D., Turnquist, Carl H.; and Bracciano, Alfred F. *Modern Refrigeration and Air Conditioning.* Homewood, Illinois: Goodheart-Willcox Co., 1975.

PROTECTION DEVICES
UNIT III

INFORMATION SHEET

I. Terms and definitions

  A. Overcurrent protection--Weak link in the circuit that limits the amperage to a specified amount

  B. Short circuit--Unintentional grounding of a conductor

  C. Circuit breaker--Overcurrent device that trips on overloads or shorts and is resettable

  D. Fuse--Overcurrent device which contains an element or elements which melt and open the circuit due to a short or overload

  E. Protection device--Electrical equipment that carries or transfers current but does not use it

  F. Ground fault interrupter--Sensitive personal protection current limiting device that opens the circuit when current leaks to ground

  G. Ferrule type cartridge fuse--Fuse with metal caps on a cylindrical case

  H. Edison base plug fuse--Fuse with a base that fits the same socket as a regular based incandescent bulb

  I. Type "S" plug fuse--Fuse with special threads for each amperage classification

  J. Blade type cartridge fuse--Fuse with flat contact blades on a cylindrical case

  K. Pressure controls--Pressure operated switch

  L. Oil failure controls--Switching device that will shut the compressor off due to low lubricating pressure

  M. Manual reset--Protection device that must be reset manually after it has interrupted the circuit due to an unusual circuit condition

  N. Automatic reset--Protection device that will reset itself after an unusual circuit condition no longer exists

  O. Pilot duty--Protection device that will interrupt the control circuit

INFORMATION SHEET

P. Line duty--Protection device that will interrupt the line voltage circuit

Q. Lockout relay--Protection device that will prevent the compressor from coming back on after it has shut off due to an unusual circuit condition and will not reset until the power is interrupted

II. Types of overcurrent protection devices (Transparency 1)

A. Blade type cartridge fuse

B. Ferrule type cartridge fuse

(NOTE: Adapters are available for using low amperage cartridge fuses in fuse holders designed for high amperage cartridge fuses.)

C. Type "S" plug fuse

(NOTE: Adapters are available for using this type of fuse in place of the Edison base plug fuse.)

D. Edison base plug fuse

E. Circuit breaker

F. Fusible link

(NOTE: These are used in cartridge type fuses which require different ampere links.)

III. Operation of a single element fuse (Transparency 2)

A. Fuses contain a current limiting link that will allow a set amount of current to exist in the circuit

B. When a short circuit or overload exists in the circuit the link becomes hot

C. The low melting point of the link causes it to break or open if the overload continues

IV. Operation of a time delay fuse (Transparency 3)

A. A time delay fuse has a spring loaded link which has one end embedded in a solder cup

B. A short circuit will cause the link to break

C. An overload will cause the solder holding the spring loaded link to soften

D. If the overload continues, the solder will soften enough to let the spring pull the link free and open the circuit

INFORMATION SHEET

V. Operation of a circuit breaker (Transparency 4)

  A. A circuit breaker has a set of internal contacts that are held together when the breaker is in the "on" position by a trigger

  B. One contact is situated on a bimetallic strip which will be under rapid heat change due to the different expansion rates of the metal

  C. If the heat becomes extreme enough, due to an overload or short, the bending of the bimetallic strip will cause the trigger to trip and the circuit will open

VI. National electric code requirements for fuses that are less than 600v

  A. Plug fuses shall not be used in circuits exceeding 125 volts between conductors

  B. Fuses shall be marked with their amperage rating

  C. Plug fuses shall be classified at not over 0 to 30 amperes

  D. Edison base plug fuses can be used only as replacements

  E. Type "S" fuses (fustats) shall be classified at not over 125 volts

  F. Type "S" fuses shall be classified at 0 to 15, 16 to 20, and 21 to 30 amperes

  G. Different ampere classes of type "S" fuses are not interchangeable

  H. Cartridge fuses shall not be used in circuits of over 300 volts between conductors

  I. Cartridge fuses shall be marked with their ampere rating, voltage rating, and the name or trademark of the manufacturer

VII. National electric code requirements for circuit breakers that are less than 600v

  A. Shall be capable of being manually tripped and set

  B. Will have a visible "off" and "on" indication

  C. Shall be designed so that setting of tripping amperage requires dismantling for other than intended adjustments

  D. Markings and ratings on breakers of less than 100 amperes shall be durable and visible after installation

INFORMATION SHEET

VIII. Types of pressure actuated protection devices (Transparency 5)

   A. Oil pressure switch

   B. Refrigerant

      1. Low pressure switch

      2. High pressure switch

      3. Dual pressure switch

IX. Pressure actuated protection devices

   A. Oil pressure (Transparency 6)

   (NOTE: The differential of the oil pressure switch is set at the factory and it is not recommended to adjust this differential in the field.)

      1. Opens compressor motor control circuit in case of low oil pressure

      2. Built-in time delay prevents nuisance shut downs

      3. Connect pressure line labeled "oil" to oil pump

      4. Connect pressure line labeled "low" to compressor motor crankcase

      5. Electrically rated for pilot duty

   B. Refrigerant low pressure (Transparency 7)

      1. Opens compressor motor control circuit if the low side pressure drops below control setting

      2. Used in air-conditioning systems to prevent the evaporator from freezing over

      3. Use in refrigeration

         a. Controls cabinet temperature

         b. Controls defrost

      4. Connects to low side of compressor

INFORMATION SHEET

C. Refrigerant high pressure (Transparency 8)

   1. Opens compressor motor control circuit when high side pressure reaches the control setting
   2. Connected to high side of system where it cannot be valved off
   3. Used in air conditioning and refrigeration
   4. Manual or automatic reset

D. Refrigerant dual pressure (Transparency 9)

   1. Combines both controls in one housing
   2. Operate independently of each other
   3. Simplifies wiring
   4. Simplifies mounting

X. Types of electrical system protection devices (Transparency 10)

A. Bimetal overload

B. Magnetic overload

C. Thermal overload relay

D. Lockout relay

E. Solid-state compressor motor protector

XI. Electrical system protection devices

A. Bimetal overloads

   1. Two types
      a. Internal
      b. External
   2. Bimetal disc opens and closes a set of contacts
   3. Increase temperature causes bimetal to warp opening motor circuit
   4. Voltages
      a. Line duty
      b. Pilot duty

INFORMATION SHEET

5. Automatic reset

6. Manual reset

   (NOTE: Manual reset bimetals are often found on heating equipment with two limit switches.)

B. Magnetic overloads

   1. Current sensitive magnetic coil
   2. Pilot duty contacts
   3. Automatic or manual reset
   4. Overload coil in series with motor winding
   5. Overload contacts in series with contactor coil

C. Thermal overload relay

   1. Current sensitive heater
   2. Pilot duty contacts
   3. Automatic or manual reset
   4. Overload relay heater in series with motor winding
   5. Overload contacts in series with contactor coil

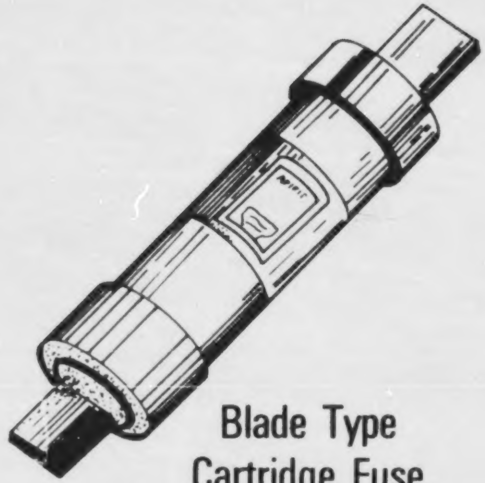
D. Lockout relay (Transparency 11)

   1. Prevents compressor motor from coming on after it stops on safety
   2. Contacts normally closed
   3. Contacts in series with overload and pressure switch contacts
   4. Coil in series with contactor coil
   5. Power must be interrupted to relay coil to restart the compressor motor

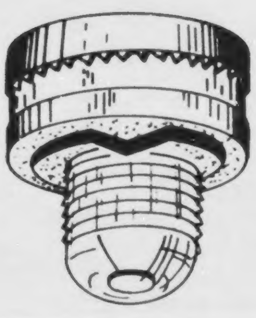
E. Solid-state compressor motor protectors

   1. Quick and sensitive reaction to temperature change
   2. Provides phase protection
   3. Sensors are enclosed in the motor windings
   4. Control module is in compressor motor terminal box

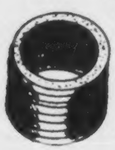
Overcurrent Protection Devices



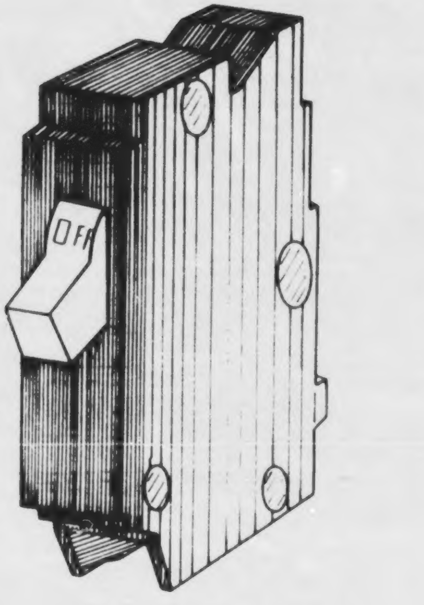
Blade Type
Cartridge Fuse



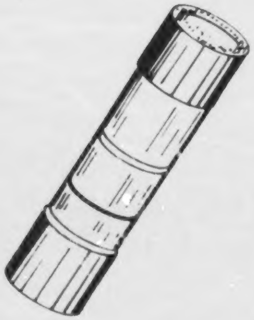
Type "S"
Plug Fuse



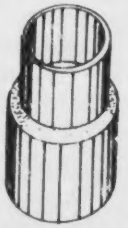
Adapter



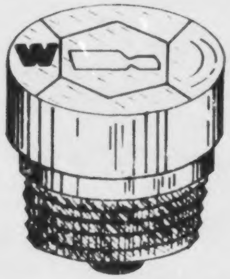
Circuit Breaker



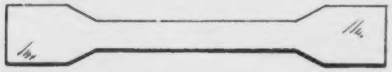
Ferrule Type Cartridge Fuse



Adapter



Edison Base Plug Fuse

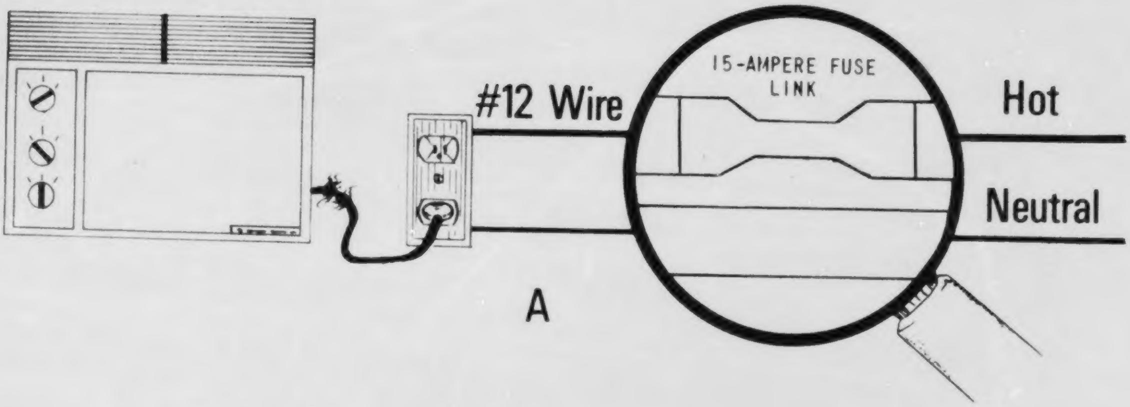


Fusible Link

TM 1

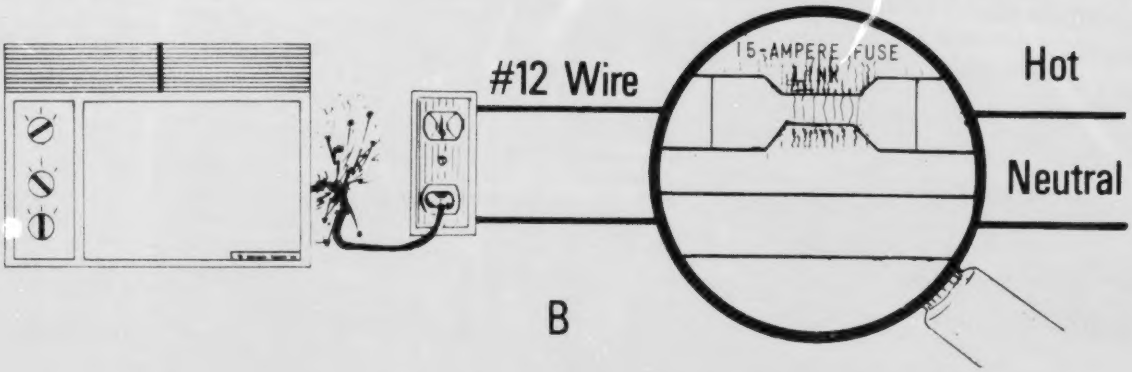
ACR II - 113-B

How A Fuse Works

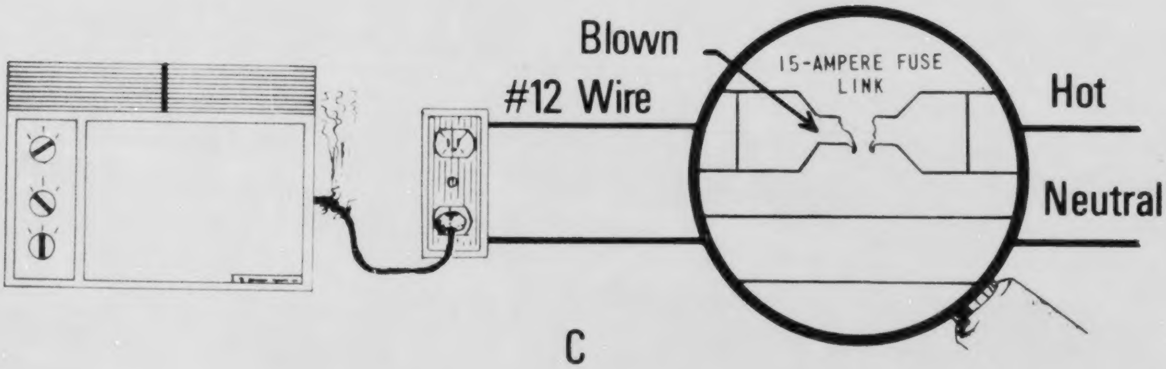

15-AMPERE FUSE LINK
#12 Wire
Hot
Neutral

A

Short Circuit

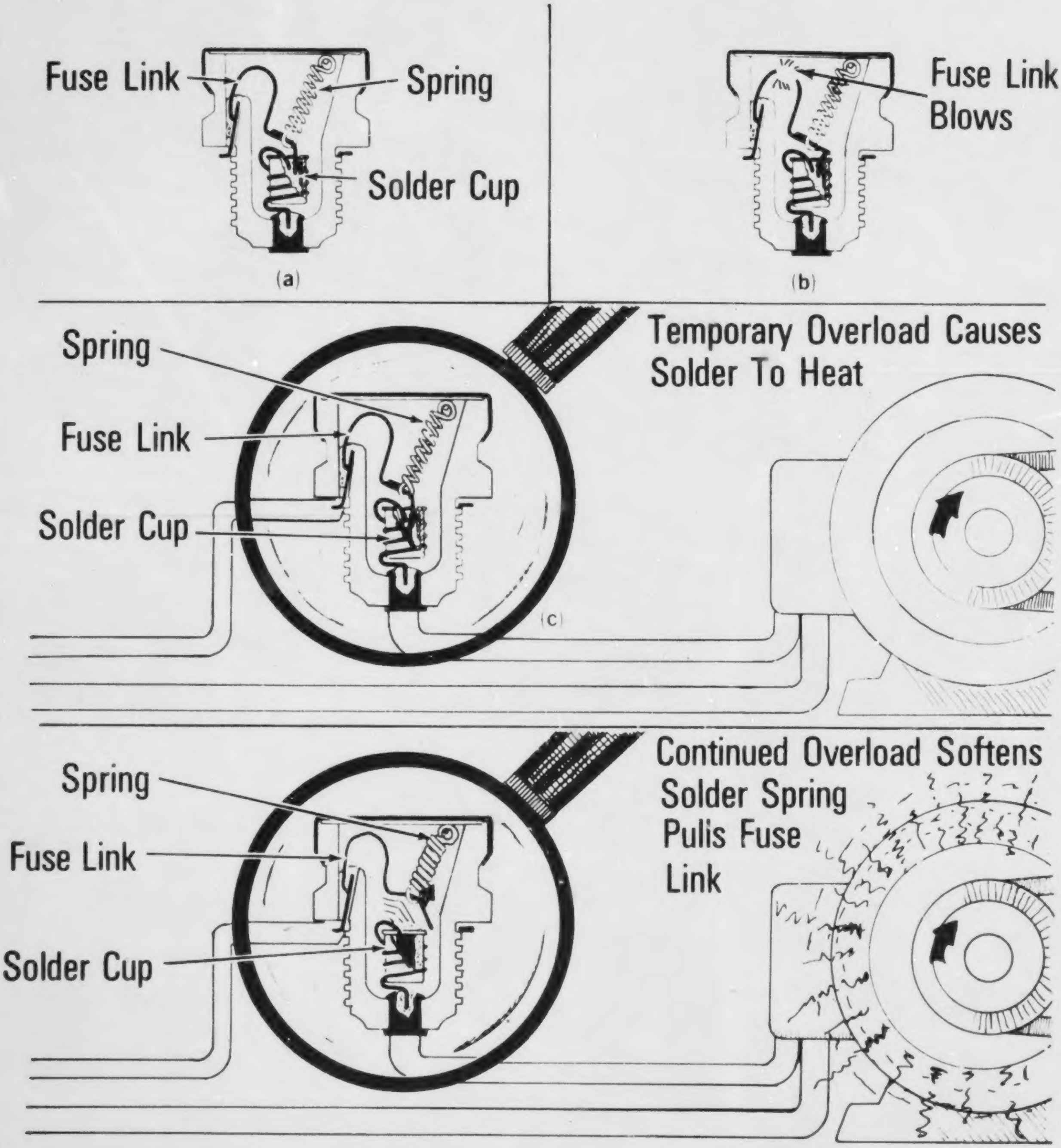

15-AMPERE FUSE LINK
#12 Wire
Hot
Neutral

B


Blown
15-AMPERE FUSE LINK
#12 Wire
Hot
Neutral

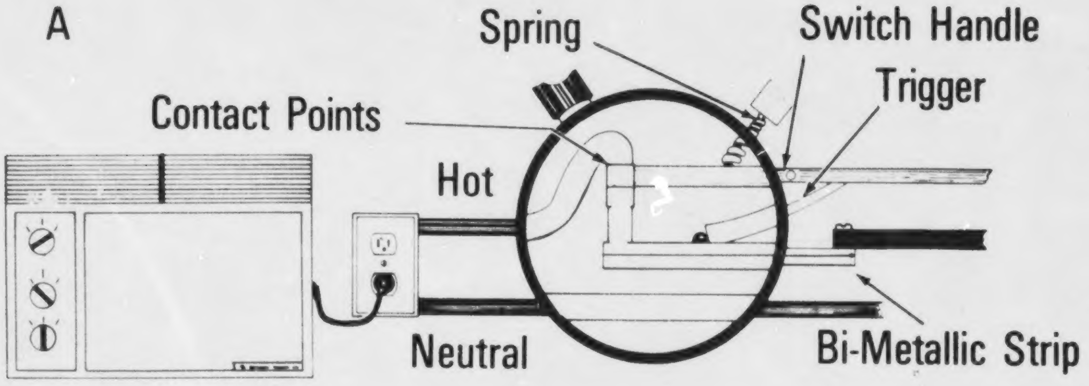
C

How A Time Delay Fuse Works

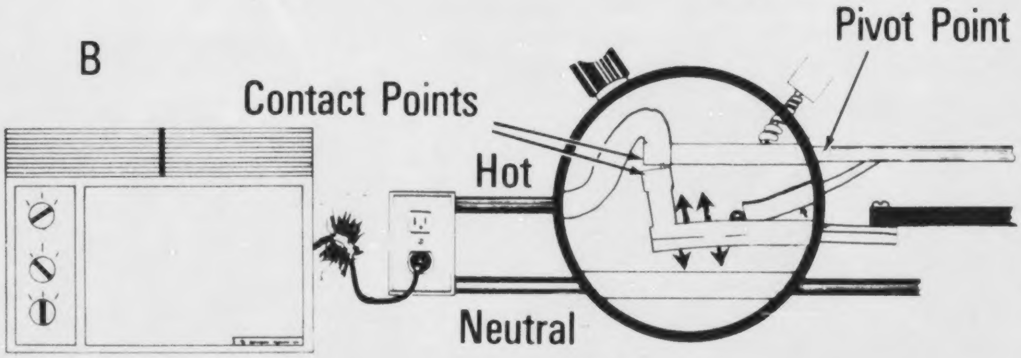

Fuse Link
Spring
Solder Cup
(a)
Fuse Link Blows
(b)
Spring
Fuse Link
Solder Cup
Temporary Overload Causes Solder To Heat
(c)
Spring
Fuse Link
Solder Cup
Continued Overload Softens Solder Spring Pulls Fuse Link

How A Circuit Breaker Works

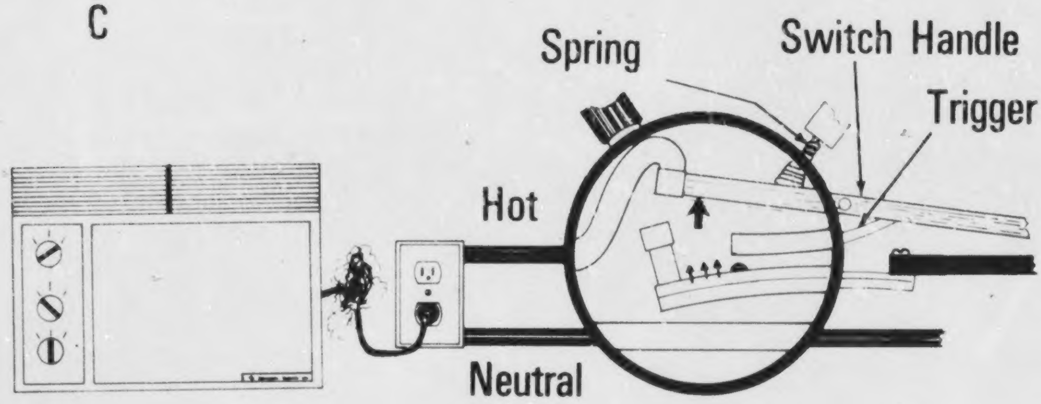
A


Spring
Switch Handle
Trigger
Contact Points
Hot
Neutral
Bi-Metallic Strip

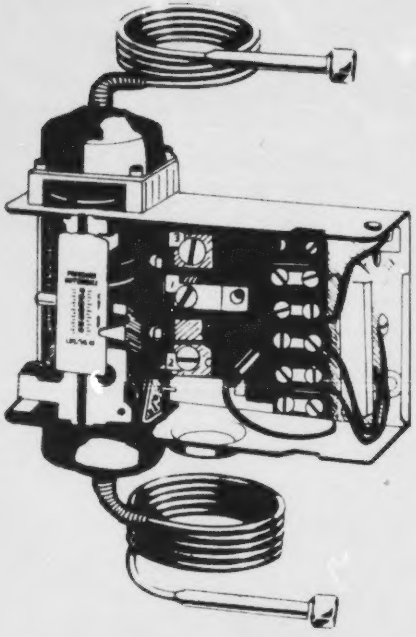
B


Pivot Point
Contact Points
Hot
Neutral

C

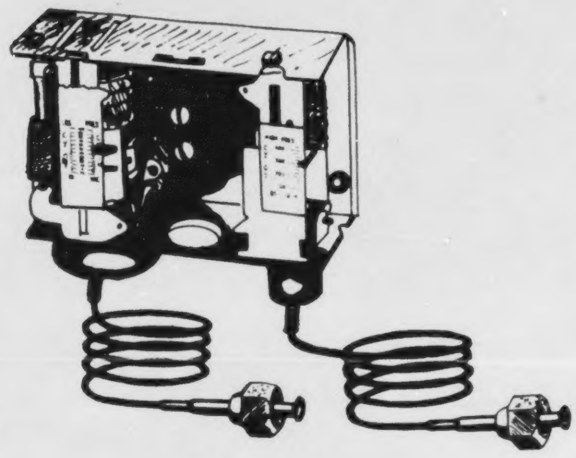

Spring
Switch Handle
Trigger
Hot
Neutral

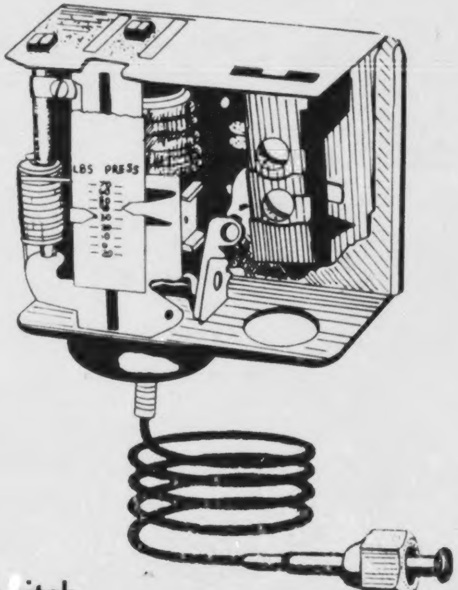
Pressure Actuated Protection Devices



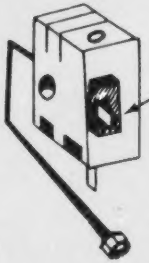
Oil Pressure Switch

Refrigerant Dual Pressure Switch





Refrigerant Low Pressure Switch

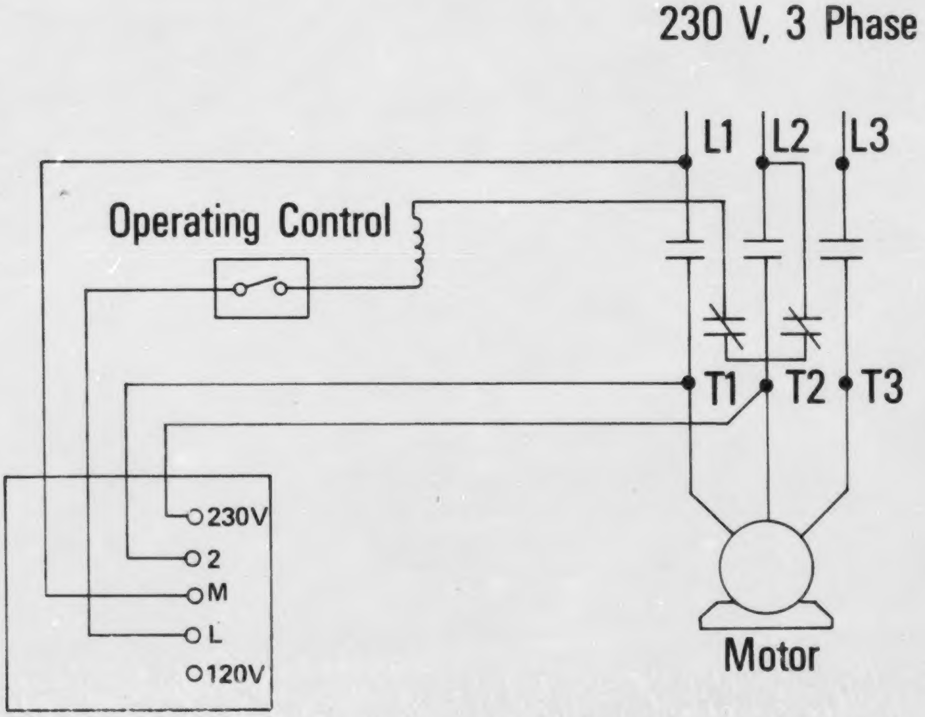


Refrigerant High Pressure Switch

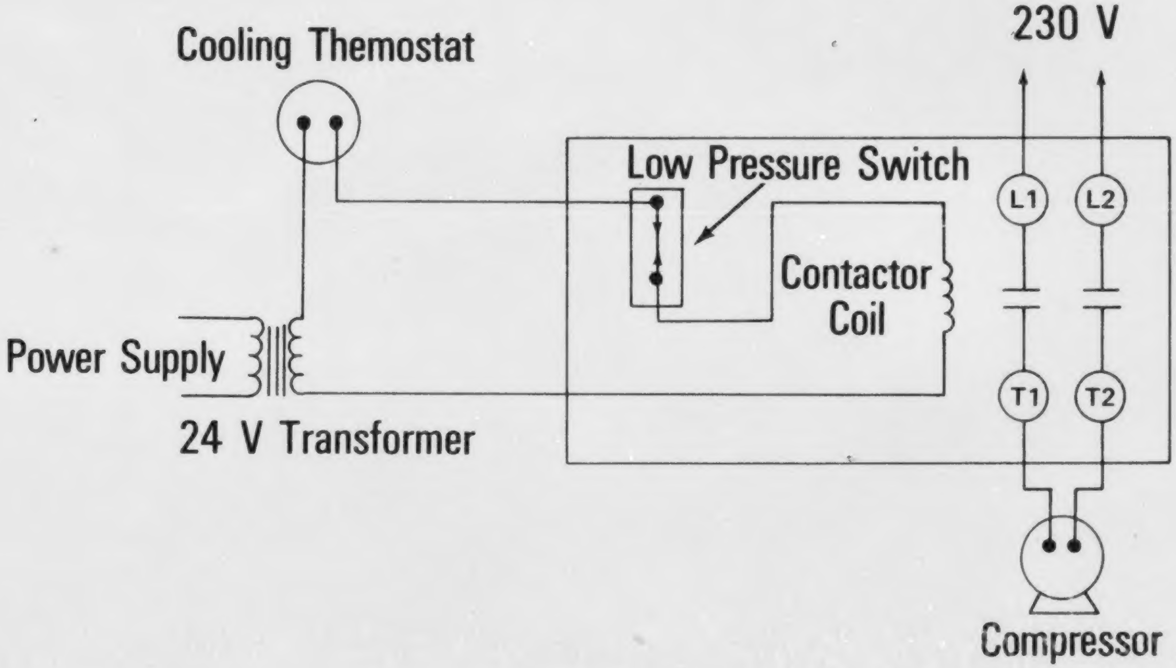
TM 5

ACR II - 121-B

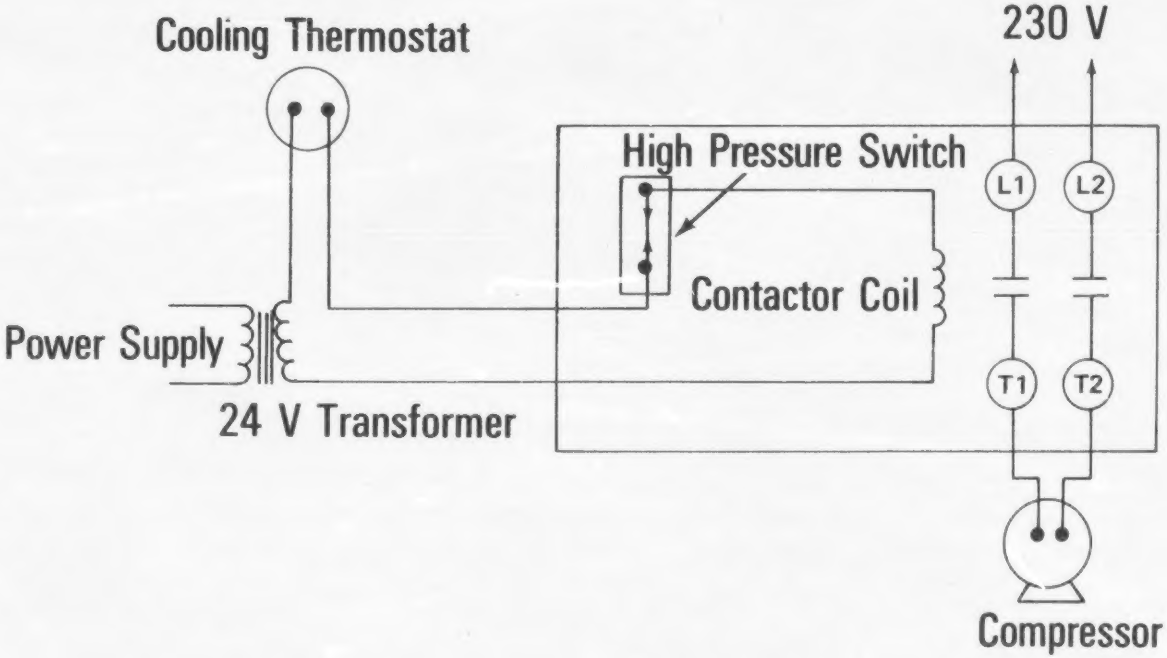
Oil Pressure Switch Wiring Diagram


230 V, 3 Phase
L1
L2
L3
Operating Control
T1
T2
T3
230V
2
M
L
120V
Motor

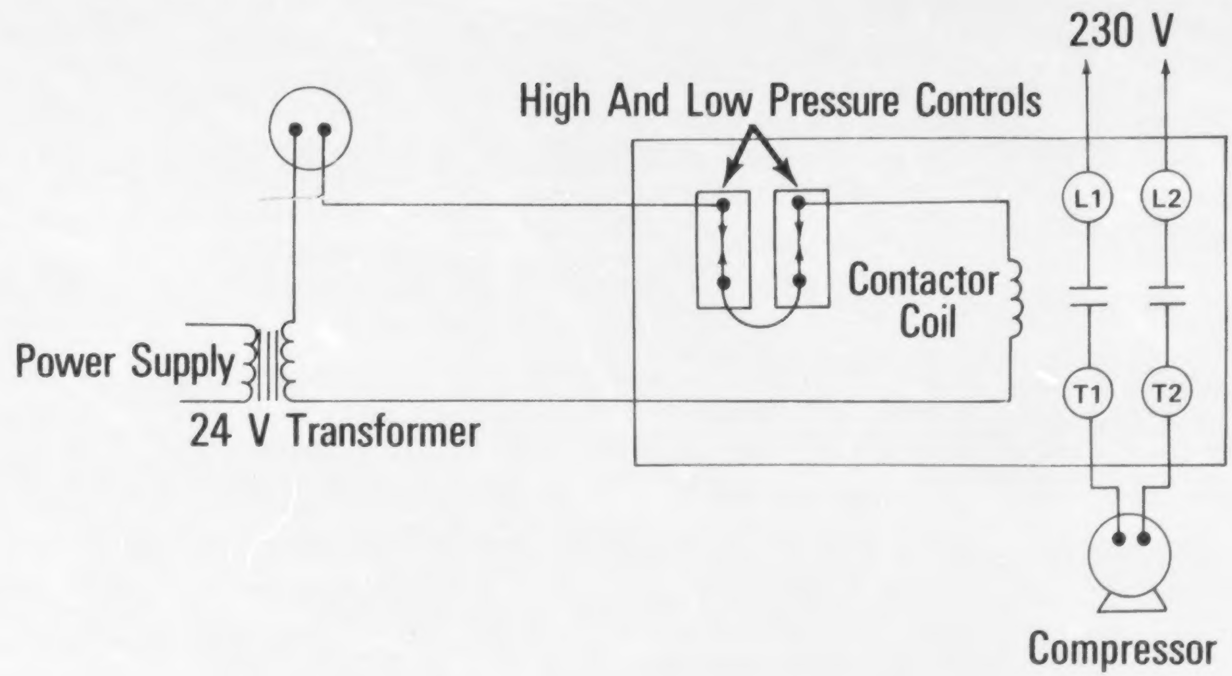
Low Pressure Switch Wiring Diagram


Cooling Themostat
230 V
Low Pressure Switch
L1
L2
Contactor Coil
Power Supply
T1
T2
24 V Transformer
Compressor

High Pressure Switch Wiring Diagram

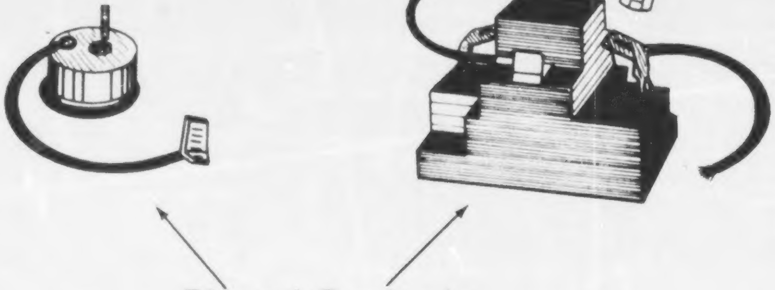

Cooling Thermostat
230 V
High Pressure Switch
L1
L2
Contactor Coil
Power Supply
T1
T2
24 V Transformer
Compressor

Dual Pressure Switch Wiring Diagram

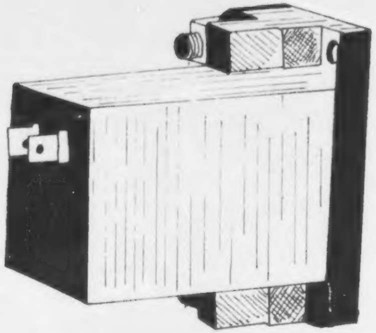


230 V
High And Low Pressure Controls
L1
L2
Contactor Coil
Power Supply
24 V Transformer
T1
T2
Compressor

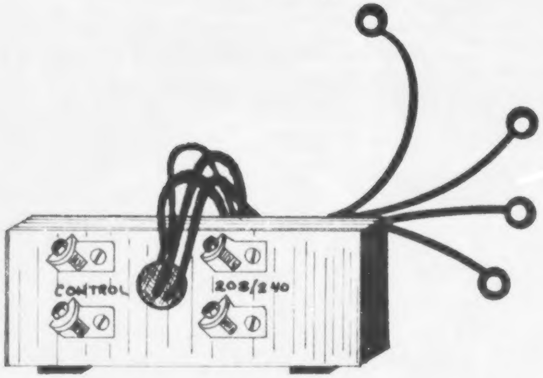
Electrical System Protection Devices



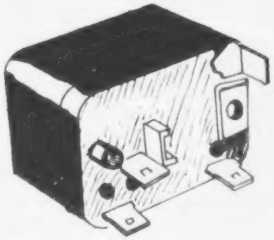
Bimetal Overloads



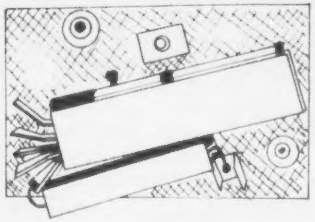
Magnetic Overload



Solid State

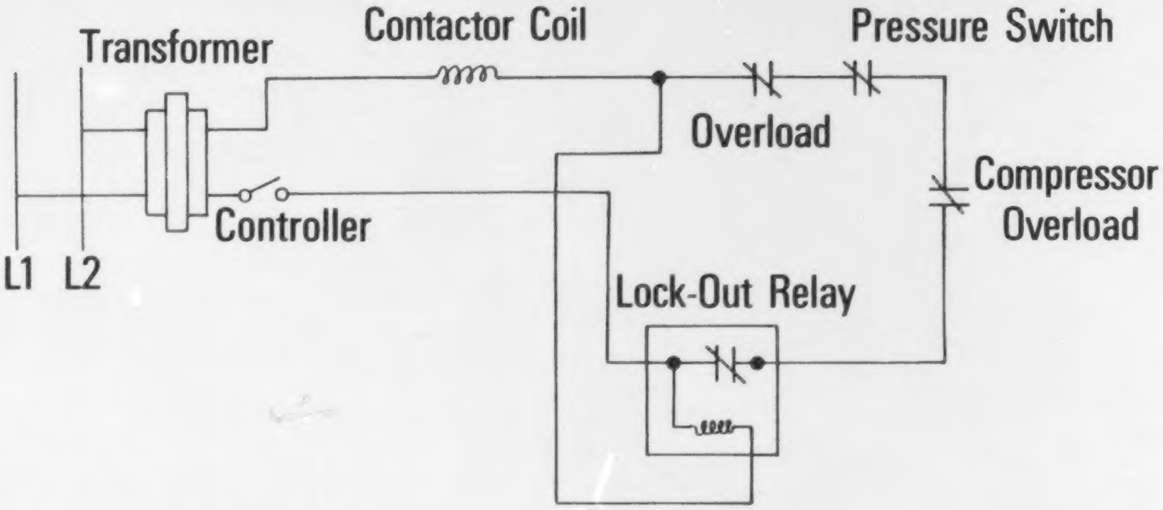


Lockout Relay



Thermal Overload Relay

Lockout Relay Wiring Diagram


Transformer
Contactor Coil
Pressure Switch
Overload
Compressor
Overload
Controller
L1
L2
Lock-Out Relay

PROTECTION DEVICES
UNIT III

JOB SHEET #1--ADJUST A HIGH PRESSURE SWITCH

I. Tools and materials

   A. Refrigeration gauge set

   B. Refrigeration ratchet

   C. Slot type screwdriver

   D. Refrigeration system with manual reset pressure switches

   E. Safety glasses

   F. Open end wrench

II. Procedure

   A. Put on safety glasses

   B. Install refrigeration gauge set

   C. Start refrigeration system

   D. Ask instructor or check manual for proper cut-out pressure

      (CAUTION: Do not exceed this pressure.)

   E. Turn adjusting screw until the pointer aligns with the proper cut-out pressure

      (NOTE: The pointer is reference only, use gauge for proper setting.)

   F. Block air or shut off circulating water

   G. Observe high side pressure reading

   H. Record pressure that the pressure switch opens

   I. Reset the pressure switch

   J. Observe high side pressure reading

   K. Have instructor check

   L. Back seat service valves

   M. Purge gauge set hoses

   N. Remove gauge set

   O. Clean up and put away tools

PROTECTION DEVICES
UNIT III

JOB SHEET #2--ADJUST A LOW PRESSURE SWITCH

I. Tools and materials

   A. Refrigeration gauge set

   B. Refrigeration ratchet

   C. Slot type screwdriver

   D. Refrigeration system with manual reset pressure switches

   E. Safety glasses

   F. Open end wrenches

II. Procedure

   A. Put on safety glasses

   B. Install refrigeration gauge set

   C. Start refrigeration system

   D. Ask instructor or check manual for proper cut-in and cut-out pressures

   E. Turn adjusting screws until the pointer aligns with the proper cut-in and cut-out pressure

   (NOTE: The pointer is reference only, use gauge for proper setting.)

   F. Front seat king valve or liquid line valve

   (NOTE: If the system is not equipped with one of these valves, partially front seat the suction service valve which will cause the low side pressure to drop.)

   G. Observe low side pressure reading

   H. Record pressure that the pressure switch opens

   I. Back seat the valve enough for the low side pressure to gradually increase

   J. Record pressure that the pressure switch closes

   K. Pump down system again

JOB SHEET #2

L. Check cut-out pressure
M. Allow low side pressure to gradually increase
N. Check cut-in pressure
O. Have instructor check
P. Reposition valves
Q. Purge gauge set hoses
R. Remove gauge set
S. Clean up and put away tools

PROTECTION DEVICES
UNIT III

JOB SHEET #3--INSTALL AN OIL PRESSURE SWITCH

I. Tools and materials

   A. Refrigeration system with a semi-hermetic compressor motor

   B. Oil pressure switch

   C. Standard slot type screwdriver

   D. Open end wrenches

   E. Two half union couplings 1/4 in. MPT x 1/4 in. flare

      (NOTE: Other fittings may be necessary depending on the brand of compressor motor used.)

   F. Refrigeration gauge set

   G. Refrigeration ratchet

   H. Vacuum pump

   I. Soap solution with brush

   J. Safety glasses

II. Procedure

   A. Put on safety glasses

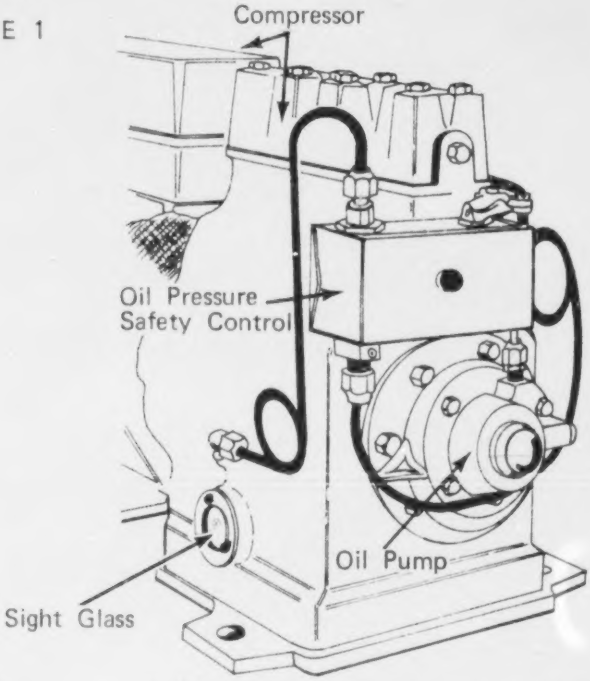
   B. Pump down system to 5 p. s. i. g.

      (NOTE: The systems low pressure switch will have to be by-passed in order to achieve pump down.)

JOB SHEET #3

C. Mount oil pressure switch bracket on the end of the compressor motor (Figure 1)

FIGURE 1



D. Carefully remove oil fill plug from compressor motor crankcase

E. Replace plug with 1/4 in. MPT X 1/4 in. flare half union coupling

F. Connect low pressure side of oil pressure switch to this coupling

(NOTE: Loop the tubing that goes to the switch to provide a vibration dampner.)

G. Remove plug from compressor oil pump

H. Replace plug with a 1/4 in. MPT X 1/4 in. flare half union coupling

I. Connect high pressure side of oil pressure switch to this coupling

J. Pressurize compressor motor with refrigerant to 50 p.s.i.g.

K. Check fittings with soap solution for leaks

L. Discharge the refrigerant used for pressurizing

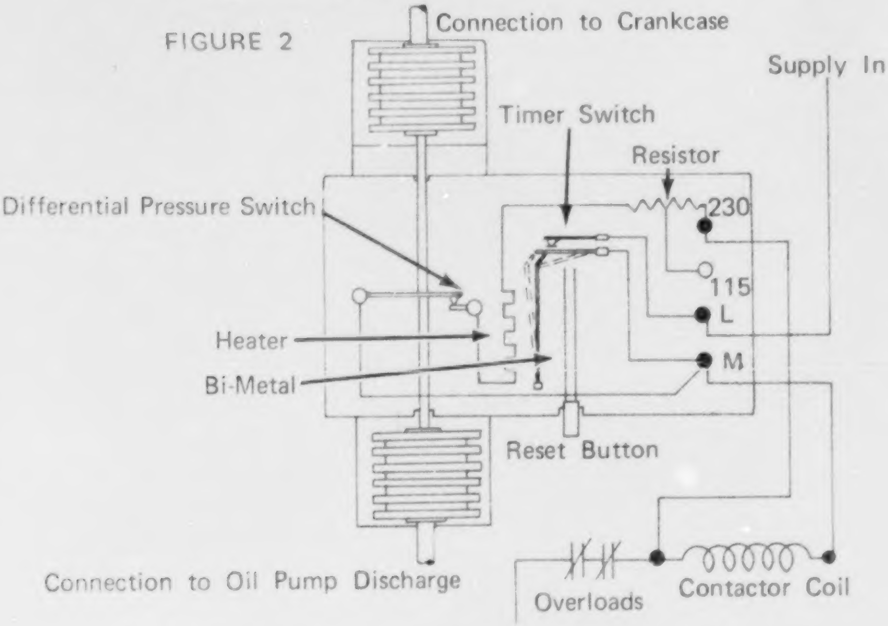
M. Evacuate compressor

JOB SHEET #3

N. Connect control wiring to oil pressure switch

(NOTE: The wiring diagram shown in Figure 2 is an example. Different control manufacturers may vary their connections some but they all are basically the same. Be sure and check the directions that come with the control you are installing.)

FIGURE 2


Connection to Crankcase
Supply In
Timer Switch
Resistor
Differential Pressure Switch
230
115
L
Heater
M
Bi-Metal
Reset Button
Connection to Oil Pump Discharge
Overloads
Contactor Coil

O. Back seat pump down valve

P. Have instructor inspect wiring

Q. Start compressor motor

(NOTE: The compressor motor will have approximately two minutes for the pressures to stabilize before the bimetal switch in the oil pressure control would stop the compressor motor.)

R. Check system pressures

S. Back seat service valves

T. Stop compressor motor

U. Purge gauge set hoses

V. Remove refrigeration gauge set

W. Replace service valve caps

X. Clean up and put away tools and materials

PROTECTION DEVICES
UNIT III

JOB SHEET #4--INSTALL A LOCKOUT RELAY

I. Tools and materials

   A. Slot type screwdriver

   B. Screw starter

   C. Long nose pliers

   D. Lockout relay

   E. Air conditioning unit with a contactor and pressure switches

   F. Safety glasses

II. Procedure

   A. Put on safety glasses

   B. Check to be sure power is disconnected from unit

   C. Locate control compartment on condensing unit

   D. Wire relay contacts in series with overload and pressure switch contacts (Figure 1)

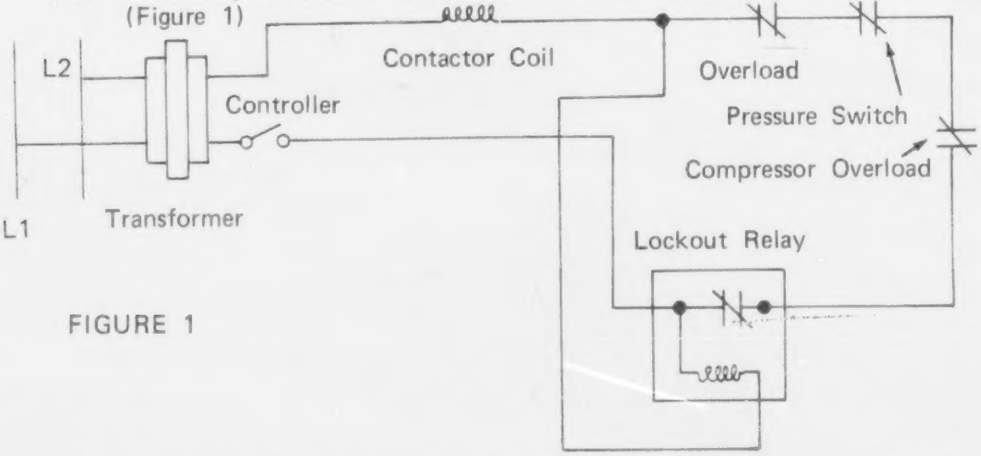

L2
Contactor Coil
Controller
Overload
Pressure Switch
Compressor Overload
L1
Transformer
Lockout Relay

FIGURE 1

   E. Wire relay coil in series with contactor coil and parallel to the safety switch contacts

   F. Have instructor inspect

   G. Turn on electricity

   H. Turn on air conditioner

JOB SHEET #4

I. Block condenser

(NOTE: Air conditioner should stop on high pressure switch.)

J. Remove condenser air blockage

K. Reset high pressure switch

(NOTE: If the lockout relay is installed properly the air conditioner will not restart.)

L. Interrupt control circuit voltage

(NOTE: This may be done at the subbase on the thermostat or at the line voltage disconnect.)

M. Connect voltage

(NOTE: Air conditioner should not start.)

N. Disconnect power supply from air conditioner

O. Clean up and put away tools

PROTECTION DEVICES
UNIT III

JOB SHEET #5--CHECK A SOLID-STATE COMPRESSOR MOTOR PROTECTOR

I. Tools and materials

- A. Jumper wires (2)
- B. Refrigeration system with solid-state compressor motor protector
- C. Safety glasses

II. Procedure

- A. Put on safety glasses
- B. Disconnect electricity from system
- C. Allow compressor motor to cool

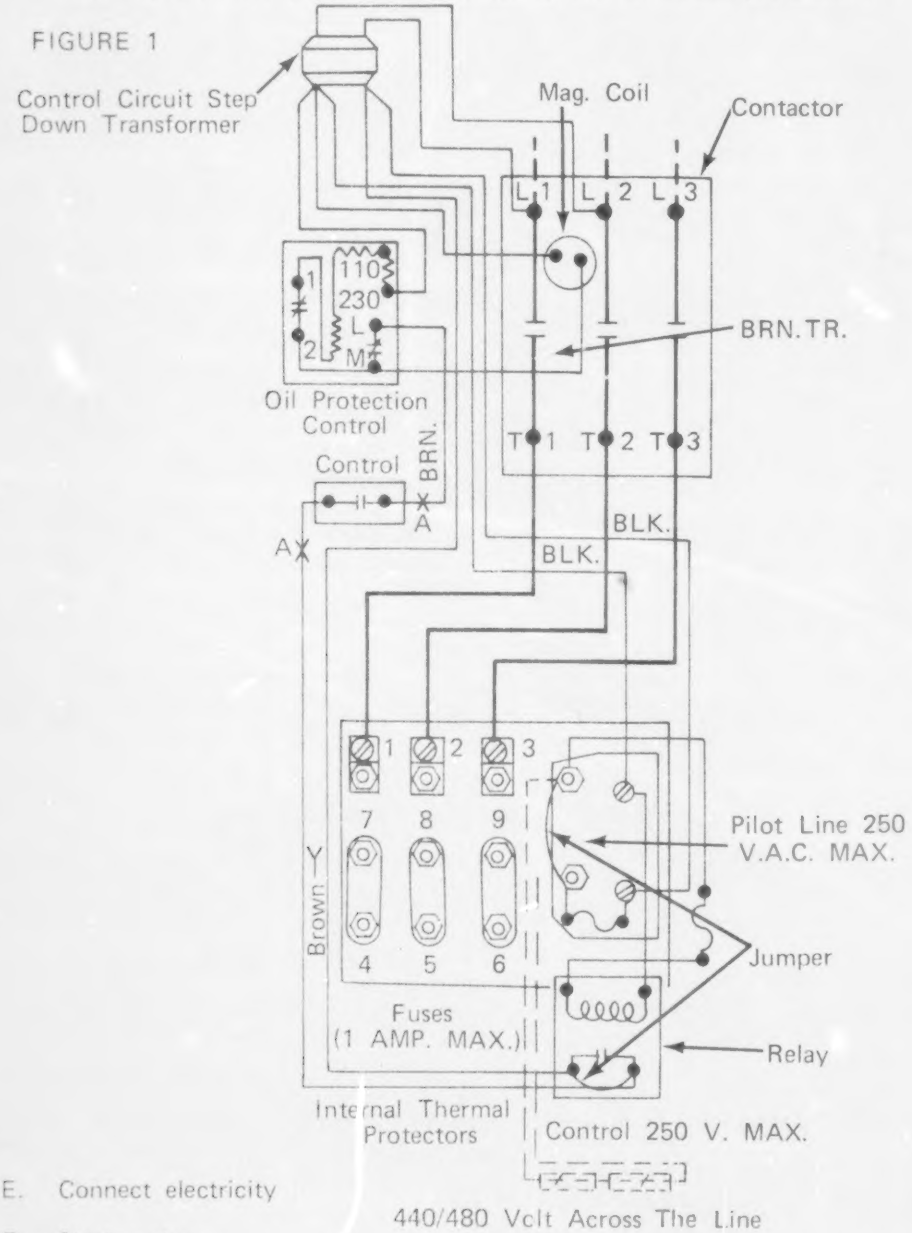
  (NOTE: If compressor motor circuit is open on the overload, it should be allowed to cool for at least one hour before checking solid-state sensors.)

JOB SHEET #5

D. Connect jumpers across the control terminals (Figure 1)

(NOTE: If the compressor motor will not operate with the jumper wires installed, then the problem is external to the solid-state protection.)

FIGURE 1


Control Circuit Step Down Transformer
Mag. Coil
Contactor
L 1
L 2
L 3
110
230
1
2
L
M
BRN.TR.
Oil Protection Control
T 1
T 2
T 3
Control
BRN.
A
A
BLK.
BLK.
1
2
3
7
8
9
4
5
6
Y
Brown
Pilot Line 250 V.A.C. MAX.
Jumper
Fuses (1 AMP. MAX.)
Relay
Internal Thermal Protectors
Control 250 V. MAX.
440/480 Volt Across The Line

E. Connect electricity

F. Start system

G. Disconnect electricity

JOB SHEET #5

H. Remove jumper from protection relay contacts

I. Connect electricity

(NOTE: If the compressor runs, the problem will be with the internal sensors. A defective internal sensor can only be repaired by compressor replacement.)

J. If the relay is defective, replace the control module

K. Have instructor check procedure

L. Clean up and put away tools

PROTECTION DEVICES
UNIT III

NAME______________________________

TEST

1. Match the terms on the right to the correct definitions.

______a. Fuse with a base that fits the same socket as a regular based incandescent bulb

______b. Overcurrent device which contains an element or elements which melt and open the circuit due to a short or overload

______c. Weak link in the circuit that limits the amperage to a specified amount

______d. Fuse with special threads for each amperage classification

______e. Sensitive personal protection current limiting device that opens the circuit when current leaks to ground

______f. Unintentional grounding of a conductor

______g. Electrical equipment that carries or transfers current but does not use it

______h. Overcurrent device that trips on overloads or shorts and is resettable

______i. Fuse with metal caps on a cylindrical case

______j. Fuse with flat contact blades on a cylindrical case

______k. Protection device that will interrupt the line voltage circuit

______l. Protection device that must be reset manually after it has interrupted the circuit due to an unusual circuit condition

1. Type "S" plug fuse
2. Protection device
3. Fuse
4. Overcurrent protection
5. Circuit breaker
6. Ferrule type cartridge fuse
7. Blade type cartridge fuse
8. Edison base plug fuse
9. Ground fault interrupter
10. Short circuit
11. Pilot duty
12. Pressure controls
13. Automatic reset
14. Oil failure controls
15. Manual reset
16. Line duty
17. Lockout relay

______m. Pressure operated switch

______n. Protection device that will interrupt the control circuit

______o. Protection device that will reset itself after an unusual circuit condition no longer exists

______p. Switching device that will shut the compressor off due to low lubricating pressure

______q. Protection device that will prevent the compressor from coming back on after it has shut off due to an unusual circuit condition and will not reset until the power is interrupted

2. Identify the types of overcurrent protection devices.

a. ______________________________

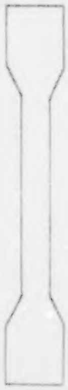
b. ______________________________

c. ______________________________

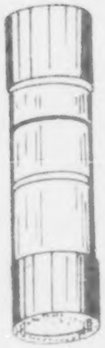
d. ______________________________

e. ______________________________

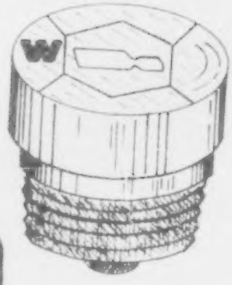
f. ______________________________



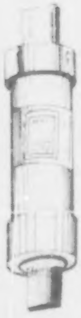
f.



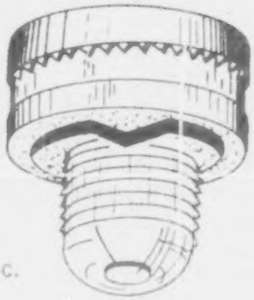
b.



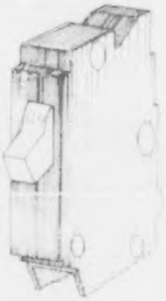
d.



a.



c.



e.

3. Describe the operation of a single element fuse.

4. Describe the operation of a time delay fuse.

5. Describe the operation of a circuit breaker.

6. List seven national electrical code requirements pertaining to fuses that are less than 600v.

   a.

   b.

   c.

   d.

   e.

   f.

   g.

7. List four national electrical code requirements pertaining to circuit breakers that are less than 600v.

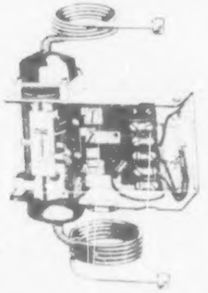
   a.

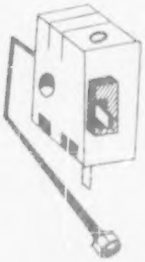
   b.

   c.

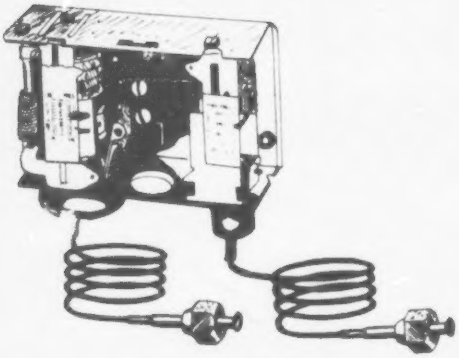
   d.

8. Identify the types of pressure actuated protection devices.

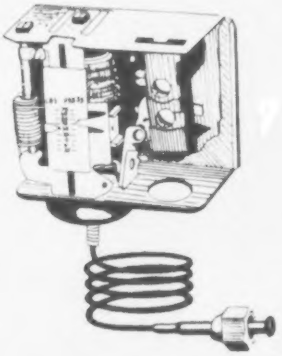




a. ______________________ b. ______________________



c. ______________________



d. ______________________

9. Describe the pressure actuated protection devices.

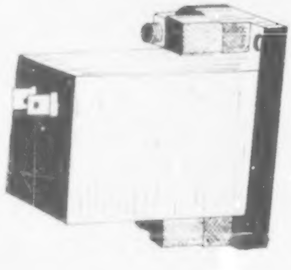
   a. Oil pressure

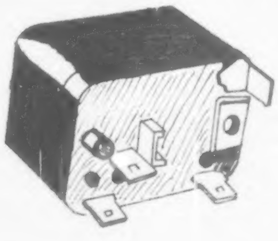
   b. Refrigerant low pressure

c. Refrigerant high pressure

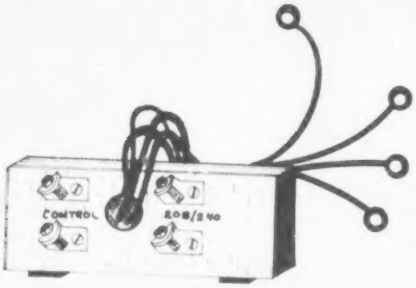
d. Refrigerant dual pressure

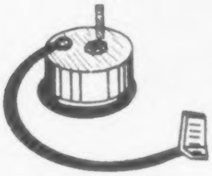
10. Identify the types of electrical system protection devices.



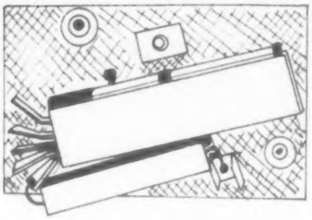


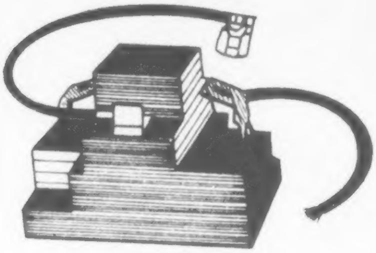
a. ______________________ b. ______________________


CONTROL
208/240



c. ____________________ d. ____________________





e. ____________________ f. ____________________

11. Describe the electrical system protection devices.

    a. Bimetal overloads

b. Magnetic overloads

c. Thermal overload relay

d. Lockout relay

e. Solid-state compressor motor protectors

12. Demonstrate the ability to:
    a. Adjust a high pressure switch.
    b. Adjust a low pressure switch.
    c. Install an oil pressure switch.
    d. Install a lockout relay.
    e. Check a solid-state compressor motor protector.

    (NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

PROTECTION DEVICES
UNIT III

ANSWERS TO TEST

1. a. 8
   b. 3
   c. 4
   d. 1
   e. 9
   f. 10
   g. 2
   h. 5
   i. 6
   j. 7
   k. 16
   l. 15
   m. 12
   n. 11
   o. 13
   p. 14
   q. 17

2. a. Blade type cartridge fuse
   b. Ferrule type cartridge fuse
   c. Type "S" plug fuse
   d. Edison base plug fuse
   e. Circuit breaker
   f. Fusible link

3. Description should include:
   a. Fuses contain a current limiting link that will allow a set amount of current to exist in the circuit
   b. When a short circuit or overload exists in the circuit the link becomes hot
   c. The low melting point of the link causes it to break or open if the overload continues

4. Description should include:
   a. A time delay fuse has a spring loaded link which has one end embedded in a solder cup
   b. A short circuit will cause the link to break
   c. An overload will cause the solder holding the spring loaded link to soften
   d. If the overload continues, the solder will soften enough to let the spring pull the link free and open the circuit

5. Description should include:

   a. A circuit breaker has a set of internal contacts that are held together when the breaker is in the "on" position by a trigger

   b. One contact is situated on a bimetallic strip which will bend under rapid heat change due to the different expansion rates of the metal

   c. If the heat becomes extreme enough, due to an overload or short, the bending of the bimetallic strip will cause the trigger to trip and the circuit will open

6. Any seven of the following:

   a. Plug fuses shall not be used in circuits exceeding 125 volts between conductors

   b. Fuses shall be marked with their amperage rating

   c. Plug fuses shall be classified at not over 0 to 30 amperes

   d. Edison base plug fuses can be used only as replacements

   e. Type "S" fuses (fustats) shall be classified at not over 125 volts

   f. Type "S" fuses shall be classified at 0 to 15, 16 to 20, and 21 to 30 amperes

   g. Different ampere classes of type "S" fuses are not interchangeable

   h. Cartridge fuses shall not be used in circuits of over 300 volts between conductors

   i. Cartridge fuses shall be marked with their ampere rating, voltage rating, and the name or trademark of the manufacturer

7. a. Shall be capable of being manually tripped and set

   b. Will have a visible "off" and "on" indication

   c. Shall be designed so that setting of tripping amperage requires dismantling for other than intended adustments

   d. Markings and ratings on breakers of less than 100 amperes shall be durable and visible after installation

8. a. Oil pressure switch

   b. Refrigerant high pressure switch

c. Refrigerant dual pressure switch

d. Refrigerant low pressure switch

9. Description should include:

a. Oil pressure

1) Opens compressor motor control circuit in case of low oil pressure

2) Built-in time delay prevents nuisance shut down

3) Connect pressure line labeled "oil" to oil pump

4) Connect pressure line labeled "low" to compressor motor crankcase

5) Electrically rated for pilot duty

b. Refrigerant low pressure

1) Opens compressor motor control circuit if the low side pressure drops below control setting

2) Used in air-conditioning systems to prevent the evaporator from freezing over

3) Use in refrigeration

a) Controls cabinet temperature

b) Controls defrost

4) Connects to low side of compressor

c. Refrigerant high pressure

1) Opens compressor motor control circuit when high side pressure reaches the control setting

2) Connected to high side of system where it cannot be valved off

3) Used in air conditioning and refrigeration

4) Manual or automatic reset

d. Refrigerant dual pressure

1) Combines both controls in one housing

    2) Operate independently of each other
    3) Simplifies wiring
    4) Simplifies mounting

10. a. Magnetic overload
    b. Lockout relay
    c. Solid-state compressor motor protector
    d. Bimetal overload
    e. Thermal overload relay
    f. Bimetal overload

11. Description should include:
    a. Bimetal overloads
        1) Two types
            a) Internal
            b) External
        2) Bimetal disc opens and closes a set of contacts
        3) Increase temperature causes bimetal to warp opening motor circuit
        4) Voltages
            a) Line duty
            b) Pilot duty
        5) Automatic reset
        6) Manual reset
    b. Magnetic overloads
        1) Current sensitive magnetic coil
        2) Pilot duty contacts

    3) Automatic or manual reset
    4) Overload coil in series with motor winding
    5) Overload contacts in series with contactor coil

  c. Thermal overload relay
    1) Current sensitive heater
    2) Pilot duty contacts
    3) Automatic or manual reset
    4) Overload relay heater in series with motor winding
    5) Overload contacts in series with contactor coil

  d. Lockout relay
    1) Prevents compressor motor from coming on after it stops on safety
    2) Contacts normally closed
    3) Contacts in series with overload and pressure switch contacts
    4) Coil in series with contactor coil
    5) Power must be interrupted to relay coil to restart the compressor motor

  e. Solid-state compressor motor protectors
    1) Quick and sensitive reaction to temperature change
    2) Provides phase protection
    3) Sensors are enclosed in the motor windings
    4) Control module is in compressor motor terminal box

12. Performance skills evaluated to the satisfaction of the instructor

CAPACITORS
UNIT IV

UNIT OBJECTIVE

After completion of this unit, the student should be able to match terms, identify capacitors, list causes of capacitor failure, and list factors to consider when replacing capacitors. The student should also be able to solve problems for capacitors in series or parallel, draw wiring diagrams for various capacitor situations and wire various capacitor circuits. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with capacitors to the correct definitions.
2. Discuss the role of capacitors in the operation of motors.
3. Identify the types of capacitors.
4. Discuss the run capacitor identified terminal.
5. List eight causes of capacitor failure.
6. List three factors to consider when replacing capacitors.
7. Solve problems for capacitors wired in series and parallel using the formulas given.
8. Draw connecting wiring for a start capacitor with a current relay and a start capacitor with a hot wire relay.
9. Draw connecting wiring for a start capacitor with a potential relay.
10. Draw connecting wiring for a run capacitor with a permanent split capacitor (P.S.C.) motor.
11. Draw connecting wiring for capacitors with a capacitor start capacitor run (C.S.R.) motor.
12. Demonstrate the ability to:
    a. Wire a start capacitor with a current or hot wire relay.
    b. Wire a start capacitor with a potential relay.
    c. Wire a run capacitor with a P.S.C. compressor motor.
    d. Wire a run capacitor with a C.S.R. compressor motor.

CAPACITORS
UNIT IV

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate and discuss the procedures outlined in the job sheets.

   G. Show students various capacitors.

   H. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Complete job sheets.

   D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM 1--Types of Capacitors

      2. TM 2--Wiring for a Start Capacitor With a Hot Wire Relay

   3. TM 3--Wiring for a Start Capacitor With a Current Relay
   4. TM 4--Wiring for a Start Capacitor With a Potential Relay
   5. TM 5--Wiring for a Run Capacitor With a Permanent Split Capacitor (P.S.C.) Motor
   6. TM 6--Capacitor Start Capacitor Run (C.S.R.) Motor

D. Job sheets

   1. Job Sheet #1--Wire a Start Capacitor With a Current or Hot Wire Relay
   2. Job Sheet #2--Wire a Start Capacitor With a Potential Relay
   3. Job Sheet #3--Wire a Run Capacitor With a P.S.C. Compressor Motor
   4. Job Sheet #4--Wire a Run Capacitor With a C.S.R. Compressor Motor

E. Test

F. Answers to test

II. References:

A. Woodroof, William Walton. *Servicing Comfort Cooling Systems*. Columbus, Ohio: NHAW Home Study Institute, 1974.

B. Van Buskirk, Mark. "Capacitor Know-How Provides Power When It's Needed Most." *Refrigeration Service and Contracting*. August, 1976.

CAPACITORS
UNIT IV

INFORMATION SHEET

I. Terms and definitions

A. Microfarad rating (mfd or μ Fd)--Amount of capacitance of a capacitor

B. Voltage rating (VAC)--Amount of peak voltage that the capacitor may be subjected to, not line voltage

C. Run capacitor--Electrical storage device in the run winding circuit of a motor generally in the 3 to 60 mfd range which is designed to stay in the circuit and has a metal case which is oil-filled for cooling

D. Start capacitor--Electrical storage device in the start winding circuit of a motor generally in the 60 mfd and higher range which is designed to be in the circuit for a very short period of time during start

E. Bleed resistor--Resistor connected between the start capacitor terminals to minimize arcing of the relay points, 20 K ohm 2 watt carbon resistor

F. Internally fused--Fusible link inside the run capacitor that will help prevent motor winding damage due to a shorted capacitor

(CAUTION: Do not discharge an internally fused capacitor with anything other than a bleed resistor because this could ruin it.)

G. Dual run capacitor--Two run capacitors built into one case

H. Hard start kit--Potential relay and a start capacitor added to a P.S.C. compressor motor to aid in starting

(NOTE: These components must be matched to the type and size of compressor motor.)

II. Role of capacitors in operation of motors

A. Capacitance reduces running current

B. Not enough capacitance will cause slow start

C. Too much or too little capacitance will cause motor to overheat

D. Capacitance aids in starting torque

INFORMATION SHEET

E. Capacitor size may be determined by motor horsepower (Figure 1)

Motor Rating HP	Capacitor Start	Capacitor Run
	MFD @ VAC	MFD @ VAC
1/8	72-88@110 75-90@110	5@236 5@330 6@330 5@370 6@370
1/6	86-103@110	7.5@236 8@330 7.5@370 7.5@440
1/4	108-130@110 124-149@110	10@236 8@330 10@330 10@370 10@440 10@440
1/3	161-193@110	15@236 12@330 14.5@330 15@330 12.5@370 15@370 15@440
1/2	200-240@110 216-259@110	15@236 15@330 15@370 15@440
3/4	324-388@110 340-408@110	17.5@250 17.5@370 20@440 20@370 20@370 20@440

FIGURE 1

(NOTE: The capacitance to use may also be determined by obtaining the voltage and amperage of the motor and using the following formula.)

$$\text{mfd} = \frac{2650 \times \text{amps}}{\text{volts}}$$

Example: 7 amps 115 volts

$$\frac{2650 \times 7}{115} = 161.3 \text{ mfd s}$$

III. Types of capacitors (Transparency 1)

A. Start capacitor

B. Run capacitor

INFORMATION SHEET

IV. Run capacitor identified terminal (Transparency 1)

   A. Connected to capacitor plate nearest the metal container

      (NOTE: This would be the plate most likely to short.)

   B. Connects to run winding of compressor motor

      (CAUTION: Damage to the start winding will occur if the capacitor is improperly wired and the capacitor becomes shorted.)

   C. Identified by three methods

      1. Arrow

      2. Red dot

      3. Dash

V. Causes of capacitor failure

   A. Faulty starting switch

   B. Excessive motor load

   C. Excessive duty cycle

   D. Bad motor bearings

   E. Low line voltage

   F. Incorrect capacitance

   G. Improper capacitor voltage rating

   H. Excessive temperature

VI. Factors for capacitor replacement

   A. Capacitor voltage rating may be higher

      (CAUTION: Never install a capacitor with a voltage rating lower than the one being replaced.)

   B. Microfarad rating of a replacement start capacitor may have a tolerance of ± 10%

      (NOTE: Replacement capacitors should be the same size as the original whenever possible.)

INFORMATION SHEET

C. Microfarad rating of a replacement run capacitor should be the same or no more than 10% higher

VII. Capacitors wired in series and parallel

A. Series (Figure 1)

1. $C_T = \frac{C1 \times C2}{C1 + C2}$

Example: 20 mfd, 110 vac, 20 mfd, 110 vac

$$C_T = \frac{20 \times 20}{20 + 20} = \frac{400}{40} = 10 \text{ mfd}$$

$$110 + 110 = 220 \text{ vac}$$

2. Sum of the voltages must be equal to or greater than the capacitor being replaced

(NOTE: Capacitor manufacturers do not recommend grouping more than two capacitors.)

3. The microfarad rating of the capacitors should be the same

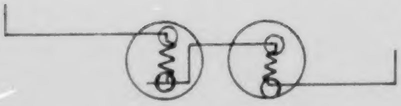
B. Parallel (Figure 2)

1. Add microfarad ratings

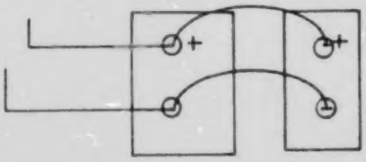
$C_T = C1 + C2$

Example: $C_T = 20 + 20 = 40$ mfd

2. Voltage of each capacitor must be equal to or greater than the capacitor being replaced



Two Start Capacitors In Series



Two Run Capacitors In Parallel

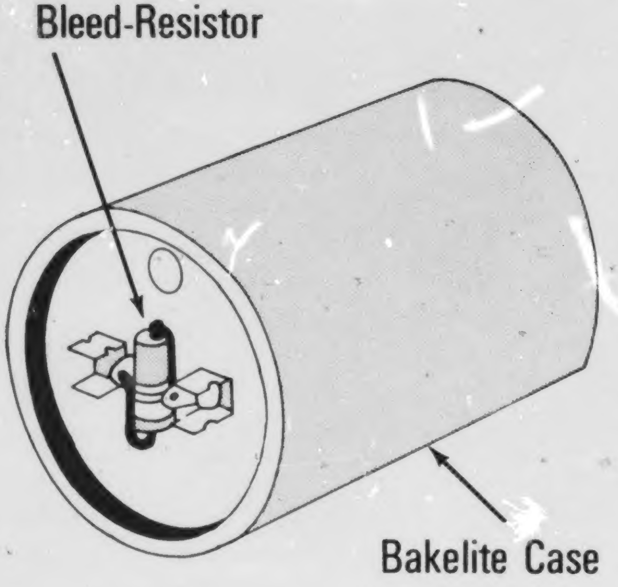
VIII. Wiring for a start capacitor with a current or hot wire relay (Transparencies 2 and 3)

IX. Wiring for a start capacitor with a potential relay (Transparency 4)

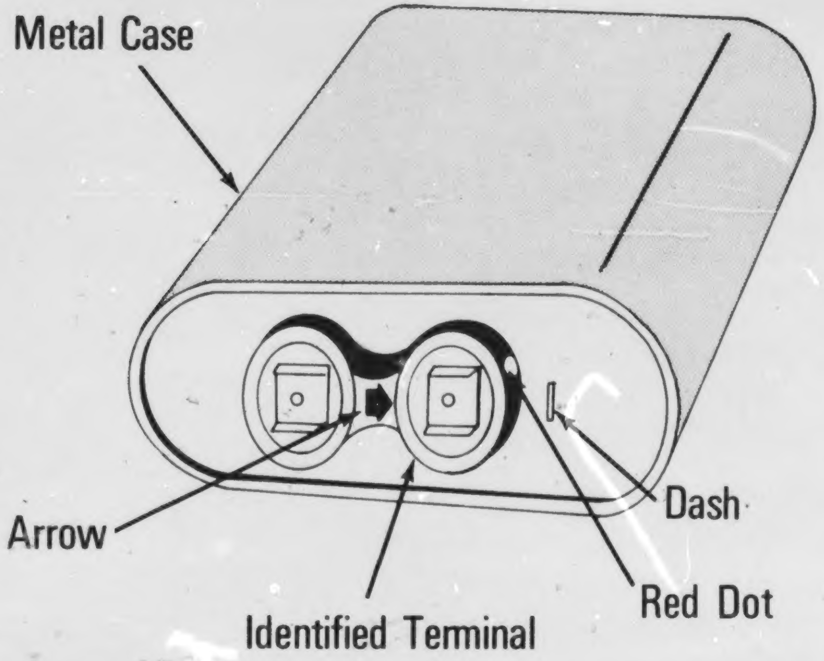
X. Wiring for a run capacitor with a permanent split capacitor (P.S.C.) motor (Transparency 5)

XI. Wiring for capacitors with a capacitor start capacitor run (C.S.R.) motor (Transparency 6)

Types Of Capacitors

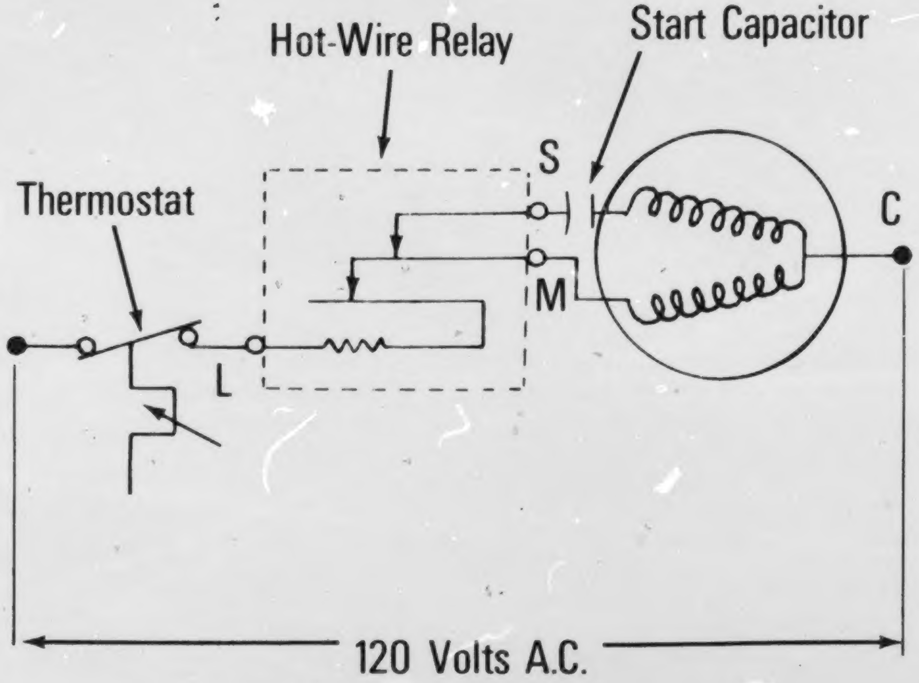

Bleed-Resistor
Bakelite Case

Start Capacitor


Metal Case
Arrow
Identified Terminal
Red Dot
Dash

Run Capacitor

Wiring For A Start Capacitor With A Hot Wire Relay


Hot-Wire Relay
Start Capacitor
S
Thermostat
C
M
L
120 Volts A.C.

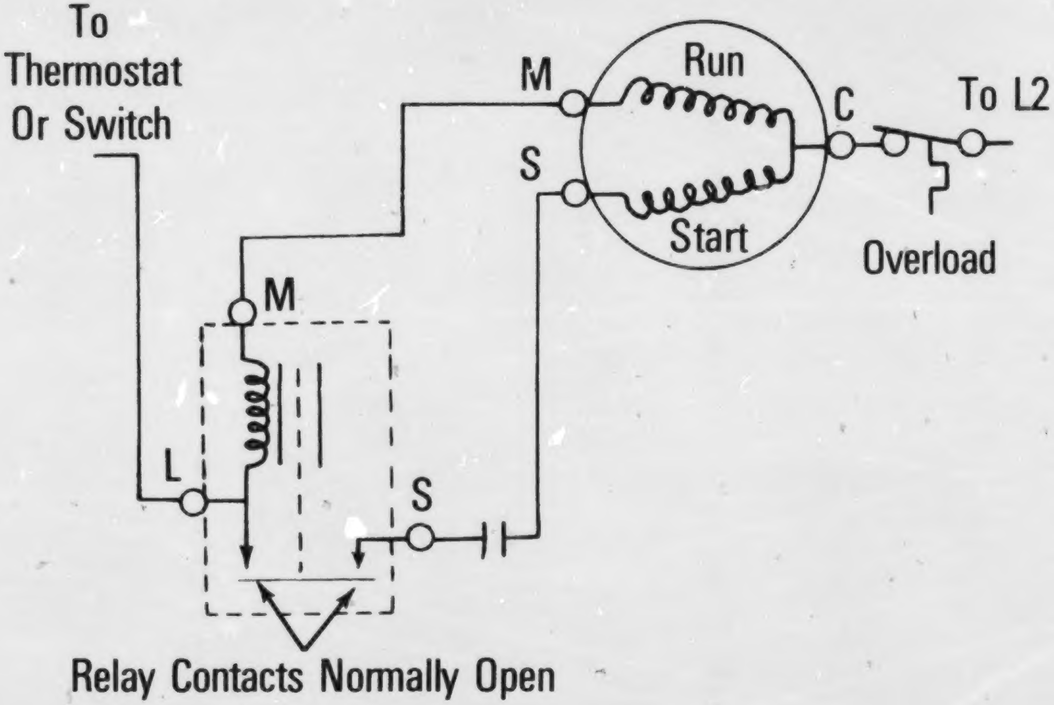
TM 2

302

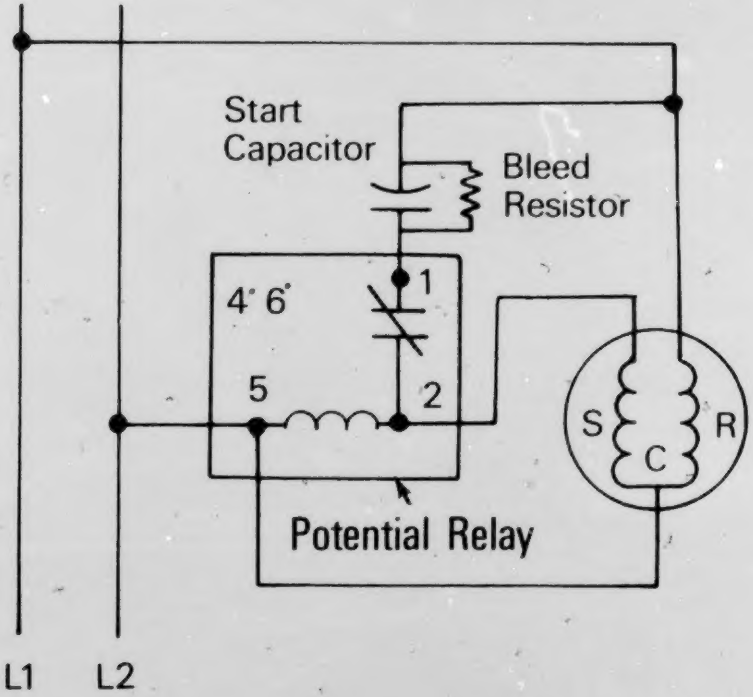
303

ACR II - 175-B

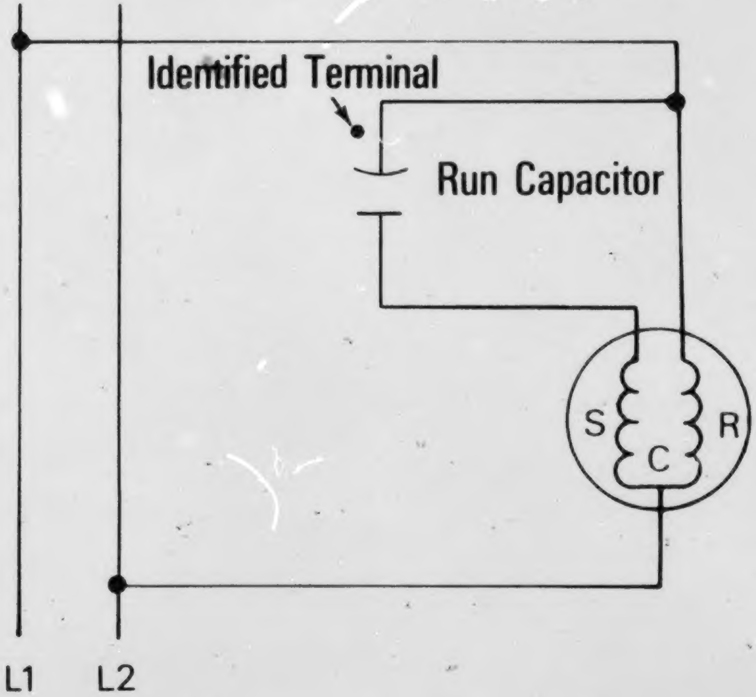
Wiring For A Start Capacitor With A Current Relay


To
Thermostat
Or Switch
M
S
Run
Start
C
To L2
Overload
M
L
S
Relay Contacts Normally Open

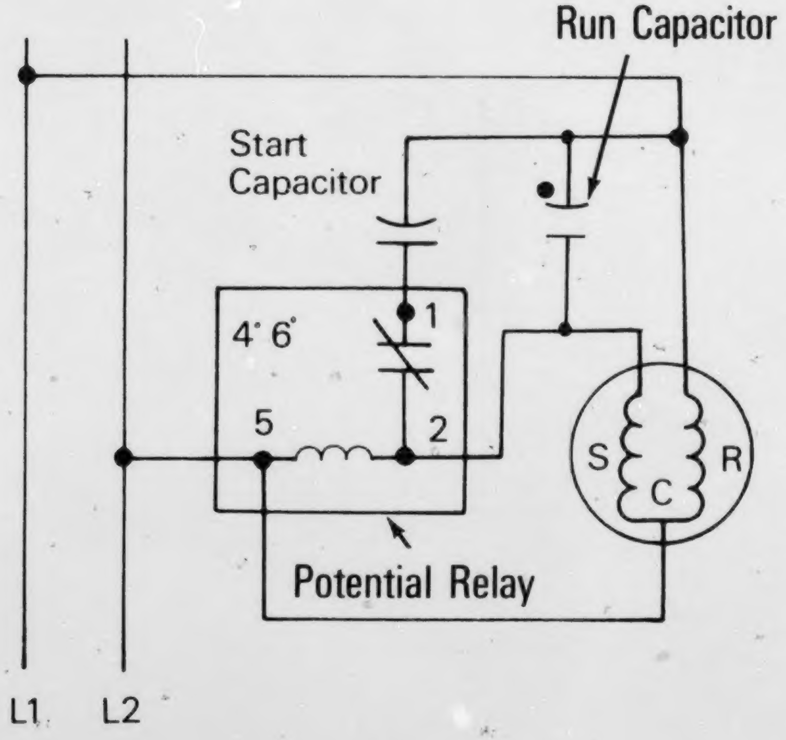
Wiring For A Start Capacitor With A Potential Relay


Start
Capacitor
Bleed
Resistor
1
4 6
5
2
S
R
C
Potential Relay
L1
L2

Wiring For A Run Capacitor With A Permanent Split Capacitor (P.S.C.) Motor


Identified Terminal
Run Capacitor
S
C
R
L1
L2

Capacitor Start Capacitor Run (C.S.R.) Motor


Run Capacitor
Start Capacitor
4 6
1
5
2
S
R
C
Potential Relay
L1
L2

CAPACITORS
UNIT IV

JOB SHEET #1--WIRE A START CAPACITOR WITH A CURRENT OR HOT WIRE RELAY

I. Tools and materials

A. Needle nose pliers

B. Standard slot screwdriver

C. Start capacitor

D. Refrigeration system with a capacitor start induction run (C.S.I.R.) compressor

E. Ammeter

II. Procedure

A. Check to be sure the electrical power is disconnected

B. Check for correct microfarad and voltage rating on capacitor

C. Connect a wire from the "S" terminal on the relay to one terminal on the start capacitor

D. Connect another wire from the other capacitor terminal to start on the compressor

(NOTE: Check wiring diagram of a start capacitor with a hot wire relay or a current relay.)

E. Have instructor inspect

F. Connect electrical power

G. Place ammeter in highest scale

H. Clamp ammeter around start wire

(NOTE: If starting circuit does not disengage immediately, disconnect electrical power.)

I. Start refrigeration system

J. Check length of time for starting circuit to disengage

K. Check full load amperage (F.L.A.)

L. Stop refrigeration system

M. Disconnect electrical power

N. Clean up and put away tools

CAPACITORS
UNIT IV

JOB SHEET #2--WIRE A START CAPACITOR WITH A POTENTIAL RELAY

I. Tools and materials

   A. Needle nose pliers

   B. Standard slot screwdriver

   C. Start capacitor with bleed resistor

   D. Refrigeration system with a potential relay

   E. Ammeter

II. Procedure

   A. Check to be sure the electrical power is disconnected

   B. Check for correct microfarad and voltage rating on capacitor

   C. Connect a wire from terminal #2 on relay to one terminal of start capacitor

   D. Connect a wire from the other start capacitor to line voltage going to run on compressor

   (NOTE: Check wiring diagram of a start capacitor with a potential relay.)

   E. Have instructor inspect

   F. Connect electrical power

   G. Place ammeter in highest scale

   H. Clamp ammeter around a start capacitor wire

   (NOTE: If starting circuit does not disengage immediately, disconnect electrical power.)

   I. Start refrigeration system

   J. Check length of time for starting circuit to disengage

   K. Check full load amperage (F.L.A.)

   L. Stop refrigeration system

   M. Disconnect electrical power

   N. Clean up and put away tools

CAPACITORS
UNIT IV

JOB SHEET #3--WIRE A RUN CAPACITOR WITH A P.S.C. COMPRESSOR MOTOR

I. Tools and materials

A. Needle nose pliers (with insulated handles)

B. Standard slot screwdriver

C. Run capacitor

D. P.S.C. motor

II. Procedure

A. Check to be sure electrical power is disconnected

B. Check for correct microfarad and voltage rating on capacitor

C. Connect a wire from the run terminal on the motor to the identified terminal on the run capacitor

(NOTE: Check wiring diagram of a run capacitor with a P.S.C. motor.)

D. Connect a wire from the start terminal on the compressor to the other side of the run capacitor

(NOTE: If this system has a dual capacitor, be sure the motor is connected to the proper terminal.)

E. Have instructor inspect

F. Connect electrical power

G. Start the equipment

H. Check full load amperage (F.L.A.)

I. With unit running, use needle nose pliers with insulated handles to remove one wire from run capacitor

(CAUTION: Do not allow the removed wire to touch you or the equipment cabinet as this would cause an electrical shock.)

J. Observe the increase in full load amperage

JOB SHEET #3

K. Stop equipment

L. Disconnect electrical power

M. Reconnect wire to run capacitor

N. Clean up and put away tools

CAPACITORS
UNIT IV

JOB SHEET #4--WIRE A RUN CAPACITOR WITH A C.S.R. COMPRESSOR MOTOR

I. Tools and materials

   A. Needle nose pliers (with insulated handles)

   B. Standard slot screwdriver

   C. Run capacitor

   D. C.S.R. motor

II. Procedure

   A. Check to be sure electrical power is disconnected

   B. Check for correct microfarad and voltage rating on capacitor

   C. Connect a wire from the capacitor identified terminal to the compressor run terminal

   D. Connect another wire from the other capacitor terminal to start on the compressor

   (NOTE: These wires are sometimes connected at other junction points within the control panel, but if you trace the circuit it will go to the run and start terminals.)

   E. Have instructor inspect

   (NOTE: This same wiring procedure is used on a P.S.C. compressor that is hard to start. Then the addition of a potential relay and start capacitor is referred to as a hard start kit.)

   F. Start the equipment

   G. Check full load amperage (F.L.A.)

   H. Stop the equipment

   I. Disconnect electrical power

   J. Clean up and put away tools

CAPACITORS
UNIT IV

NAME________________________

TEST

1. Match the terms on the right to the correct definitions.

______a. Amount of peak voltage that the capacitor may be subjected to, not line voltage

______b. Two run capacitors built into one case

______c. Fusible link inside the run capacitor that will help prevent motor winding damage due to a shorted capacitor

______d. Amount of capacitance of a capacitor

______e. Electrical storage device in the run winding circuit of a motor generally in the 3 to 60 mfd range which is designed to stay in the circuit and has a metal case which is oil-filled for cooling

______f. Resistor connected between the start capacitor terminals to minimize arcing of the relay points, 20 K ohm 2 watt carbon resistor

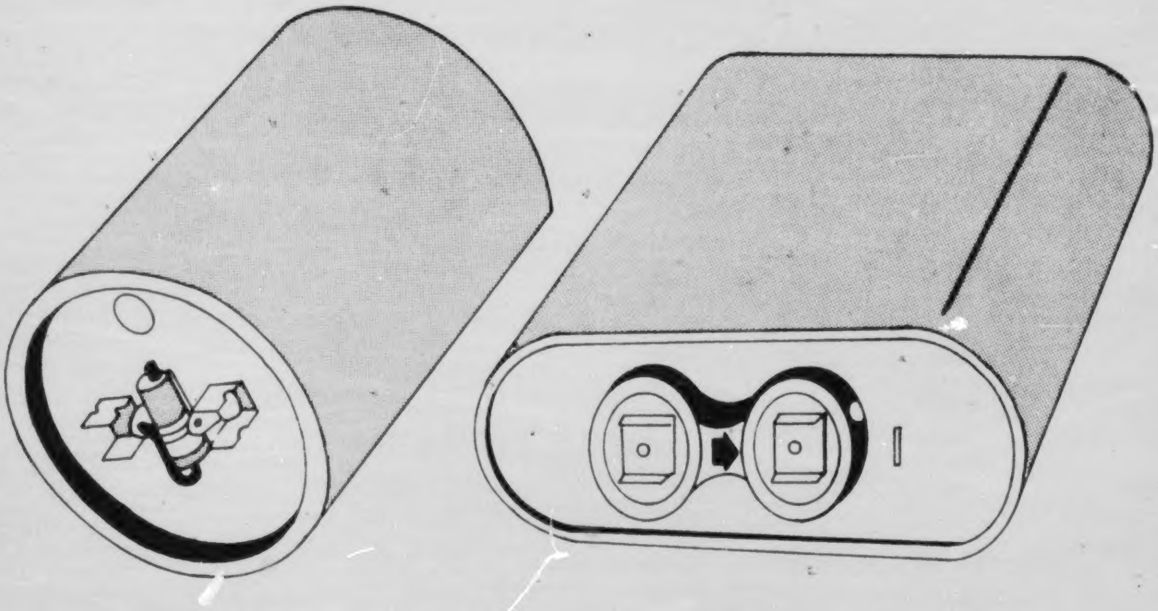
______g. Potential relay and a start capacitor added to a P.S.C. compressor motor to aid in starting

______h. Electrical storage device in the start winding circuit of a motor generally in 60 mfd and higher range which is designed to be in the circuit for a very short period of time during start

1. Bleed resistor
2. Dual run capacitor
3. Microfarad rating (mfd or μ Fd)
4. Hard start kit
5. Run capacitor
6. Voltage rating (VAC)
7. Internally fused
8. Start capacitor

2. Discuss the role of capacitors in the operation of motors.

3. Identify the types of capacitors.



a. ____________________ b. ____________________

4. Discuss the run capacitor identified terminal.

5. List eight causes of capacitor failure.

   a.

   b.

   c.

   d.

   e.

   f.

   g.

   h.

6. List three factors to consider when replacing capacitors.

   a.

   b.

   c.

7. Solve these problems for capacitors wired in series and parallel using the formulas given.

   Capacitors in series $C_T = \frac{C1 \times C2}{C1 + C2}$

   Capacitors in parallel $C_T = C1 + C2$

a. Series

1. 5 mfd, 110 VAC, 5 mfd, 110 VAC

   ans. ______mfd ______VAC

2. 160 mfd, 250 VAC, 160 mfd, 350 VAC

   ans. ______mfd ______VAC

3. 140 mfd, 270 VAC, 140 mfd, 270 VAC

   ans. ______mfd ______VAC

4. 10 mfd, 250 VAC, 10 mfd, 110 VAC

   ans. ______mfd ______VAC

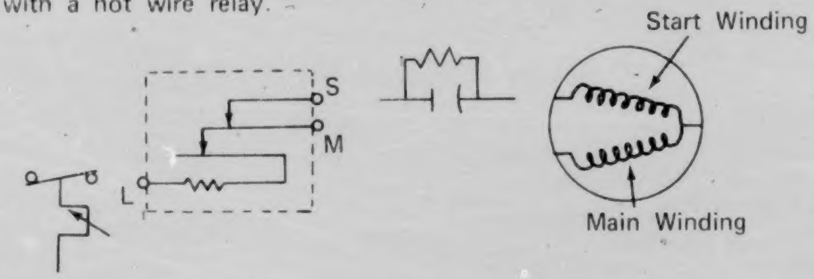
5. 35 mfd, 250 VAC, 35 mfd, 440 VAC

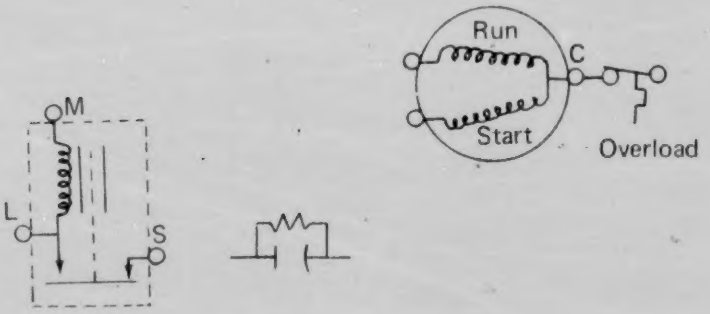
   ans. ______mfd ______VAC

b. Parallel

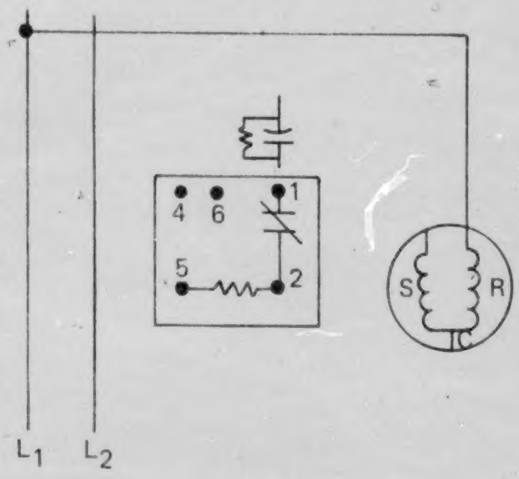
1. 5 mfd, 10 mfd ans. ______mfd
2. 20 mfd, 160 mfd ans. ______mfd
3. 140 mfd, 140 mfd ans. ______mfd
4. 10 mfd, 10 mfd ans. ______mfd
5. 35 mfd, 160 mfd ans. ______mfd

8. Draw connecting wiring for a start capacitor with a current relay and a start capacitor with a hot wire relay.

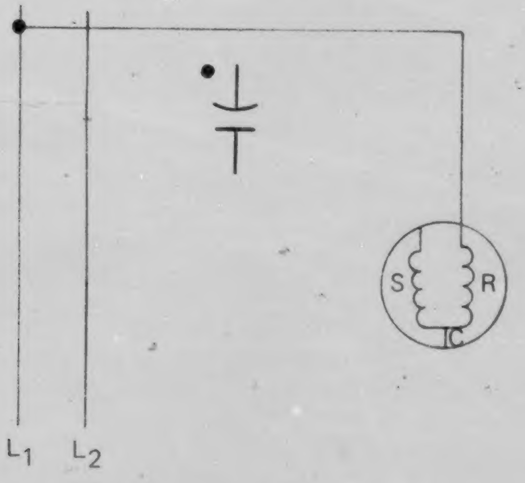

Start Winding
S
M
L
Main Winding


Run
C
Start
Overload
M
L
S

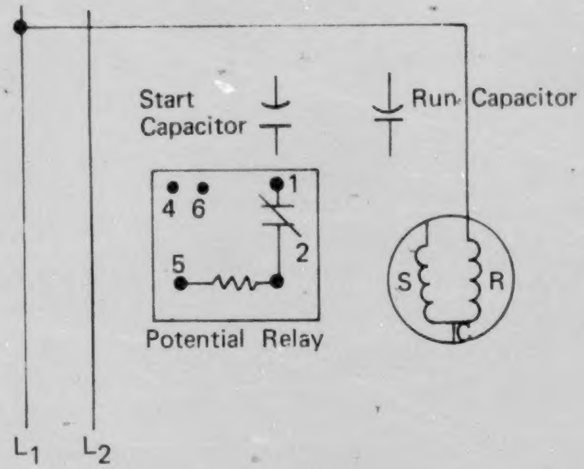
9. Draw connecting wiring for a start capacitor with a potential relay.


4
6
1
5
2
S
R
C
L1
L2

10. Draw connecting wiring for a run capacitor with a permanent split capacitor (P.S.C.) motor.



11. Draw connecting wiring for capacitors with a capacitor start capacitor run (C.S.R.) motor.


Start Capacitor
Run Capacitor
4
6
1
2
5
Potential Relay
S
R
C
L1
L2

12. Demonstrate the ability to:

a. Wire a start capacitor with a current or hot wire relay.

b. Wire a start capacitor with a potential relay.

c. Wire a run capacitor with a P.S.C. compressor motor.

d. Wire a run capacitor with a C.S.R. compressor motor.

(NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

CAPACITORS
UNIT IV

ANSWERS TO TEST

1. a. 6
   b. 2
   c. 7
   d. 3
   e. 5
   f. 1
   g. 4
   h. 8

2. Discussion should include:
   a. Capacitance reduces running current
   b. Not enough capacitance will cause slow start
   c. Too much or too little capacitance will cause motor to overheat
   d. Capacitance aids in starting torque
   e. Capacitor size may be determined by motor horsepower

3. a. Start capacitor
   b. Run capacitor

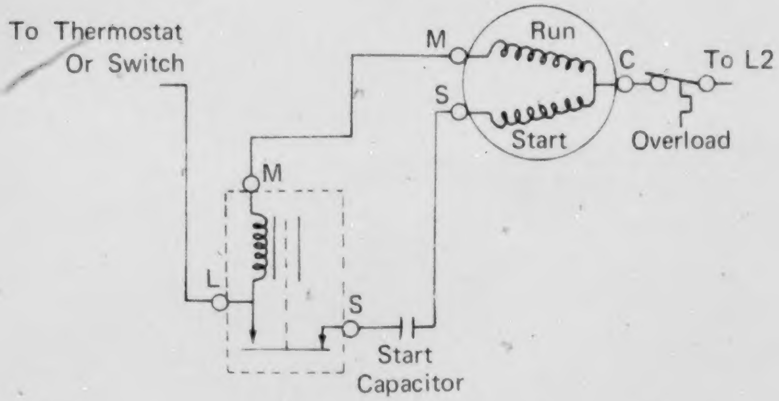
4. Discussion should include:
   a. Connected to capacitor plate nearest the metal container
   b. Connects to run winding of compressor motor
   c. Identified by three methods
      1) Arrow
      2) Red dot
      3) Dash

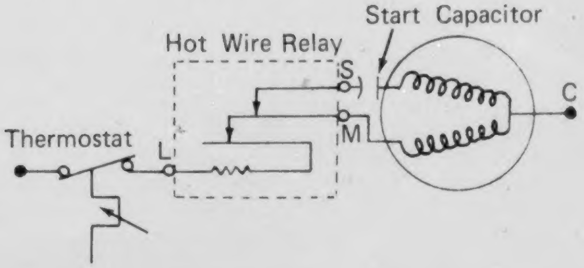
5. a. Faulty starting switch
   - b. Excessive motor load
   - c. Excessive duty cycle
   - d. Bad motor bearings
   - e. Low line voltage
   - f. Incorrect capacitance
   - g. Improper capacitor voltage rating
   - h. Excessive temperature

6. a. Capacitor voltage rating may be higher
   - b. Microfarad rating of a replacement start capacitor may have a tolerance of ± 10%
   - c. Microfarad rating of a replacement run capacitor should be the same or no more than 10% higher

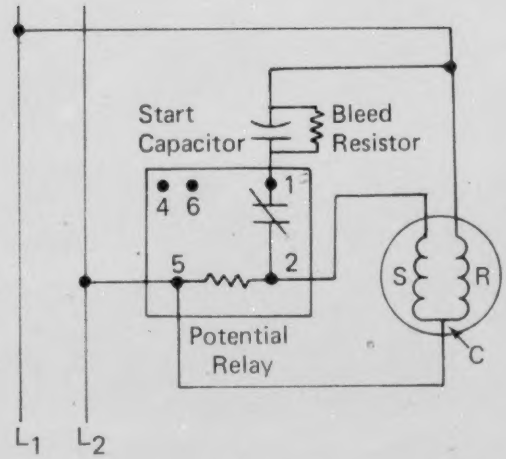
7. a. Series
      - 1) 2.5 mfd 220 VAC
      - 2) 80 mfd 600 VAC
      - 3) 70 mfd 540 VAC
      - 4) 5 mfd 360 VAC
      - 5) 17.5 mfd 690 VAC
   - b. Parallel
      - 1) 15 mfd
      - 2) 180 mfd
      - 3) 280 mfd
      - 4) 20 mfd
      - 5) 195 mfd

8.

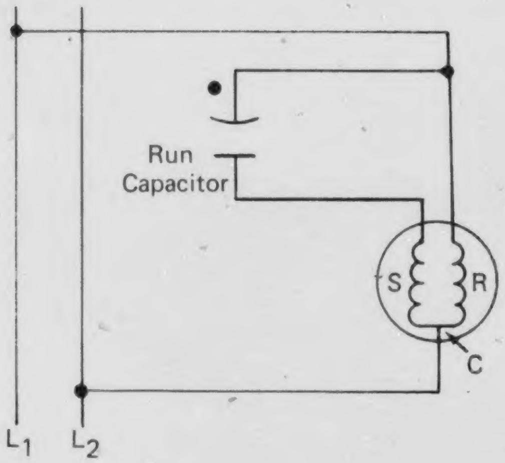

To Thermostat Or Switch
M
Run
C
To L2
S
Start
Overload
M
L
S
Start Capacitor


Start Capacitor
Hot Wire Relay
S
C
Thermostat
L
M

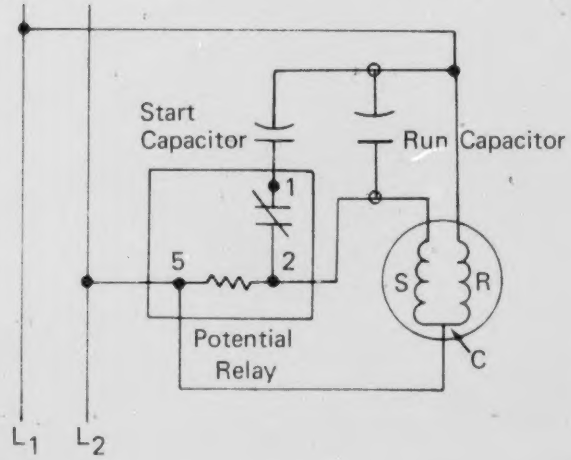
9.


Start Capacitor
Bleed Resistor
4
6
1
2
5
S
R
C
Potential Relay
L1
L2

10.


Run
Capacitor
S
R
C
L1
L2

11.


Start
Capacitor
Run Capacitor
1
5
2
S
R
Potential
Relay
C
L1
L2

12. Performance skills evaluated to the satisfaction of the instructor

INTRODUCTION TO ELECTRIC MOTORS
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to match terms, list safety rules, discuss magnetism and three-phase motors, and identify parts of a motor. The student should also be able to list types of single-phase motors, read motor data plates, and solve problems, determine V-belt length, and adjust belt tension. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with electric motors to the correct definitions.
2. List safety rules pertaining to working with electric motors.
3. Discuss magnetism.
4. Discuss magnets in an induction type motor.
5. List types of single-phase motors.
6. Identify parts of an open drive motor.
7. Identify the common types of motor mounts.
8. Discuss motor enclosures.
9. Discuss three-phase motors.
10. List the fourteen items of information provided on a motor data plate.
11. Identify the types of motor V-pulleys (sheaves)
12. Solve problems using a method for determining pulley size.
13. List causes of motor problems.
14. List remedies of motor problems.
15. Demonstrate the ability to:
    a. Determine length of a V-belt.
    b. Adjust V-belt tension.

INTRODUCTION TO ELECTRIC MOTORS
UNIT I

SUGGESTED ACTIVITIES

I. Instructor:

  A. Provide student with objective sheet.

  B. Provide student with information, assignment, and job sheets.

  C. Make transparencies.

  D. Discuss unit and specific objectives.

  E. Discuss information and assignment sheets.

  F. Demonstrate and discuss the procedures outlined in the job sheets.

  G. Obtain films or slide sets on electric motor fundamentals.

  H. Give test.

II. Student:

  A. Read objective sheet.

  B. Study information sheet.

  C. Complete assignment and job sheets.

  D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

  A. Objective sheet

  B. Information sheet

  C. Transparency masters

    1. TM 1--Attraction and Repulsion of Charges

    2. TM 2--Electric Motor

    3. TM 3--Parts of an Open Drive Motor

    4. TM 4--Types of Motor Mounts
    5. TM 5--Three-Phase Motor
    6. TM 6--Motor Data Plate
    7. TM 7--Types of Motor V-Pulleys (Sheaves)

D. Assignment Sheet #1--Give the Remedy to Motor Problems

E. Answers to assignment sheet

F. Job sheets

    1. Job Sheet #1--Determine Length of a V-Belt
    2. Job Sheet #2--Adjust V-Belt Tension

G. Test

H. Answers to test

II. References:

A. Schweitzer, Gerald. *Basics of Fractional Horsepower Motors and Repair.* Rochelle Park, New Jersey: Hayden Book Co., February 1960.

B. Turner, J. Howard. *How Electric Motors Start and Run.* Athens, Georgia: American Association for Vocational Instructional Materials, 1973.

C. Parady, W. Harold; Turner, J. Howard; and Wren, James E. *Electric Motors.* Athens, Georgia: American Association for Vocational Instructional Materials, January 1972.

INTRODUCTION TO ELECTRIC MOTORS
UNIT I

INFORMATION SHEET

I. Terms and definitions

A. Poles--Soft iron, laminated portion of the stator which the insulated wire is wound around

B. Stator--Stationary section that consists of the windings and core which form the electromagnet that produces the magnetic field causing the motor to turn

C. Rotor--Rotating section which rotates within the stator of a motor

D. Synchronous speed--Constant speed to which an alternating current motor adjusts itself, depending on the frequency of the power supply and the number of poles in the motor

E. Induction motor--Alternating current motor in which the stator is connected to the power source; this induces current into a secondary winding called the rotor

F. Repulsion motor--Single-phase motor which incorporates a commutator and brushes

G. Deflection--Deviation from a standard

Example: Pressing down on a V-belt to check for the amount of slack

H. NEMA (National Electrical Manufacturer's Association)--Establishes certain voluntary standards relating to motors

I. Resilient mount--Rubber support on each end of the motor which cushions the motor base from vibrations

J. Rigid mount--Mounting brackets are permanently attached to the motor frame

K. Slip--Difference between the synchronous speed of a motor and the speed at which it operates

L. Shunt--A low resistance conductor which connects two parts of a circuit in parallel

II. Safety rules

A. Don't underestimate the potential danger of a 110 VAC curcuit

B. Be careful around electric arcs because they will cause bad burns to skin and eyes

C. Remember that involuntary reaction to electric shock can cause you to injure yourself and possibly others

INFORMATION SHEET

D. Do not work on live circuits except when absolutely necessary

E. Never install equipment that will overload a circuit

F. Never bypass electrical protective devices

G. All electrical lines must be properly fused

H. Protect all electrical wires when routing them over refrigerant tubing

I. All electrical wiring must be well insulated

J. Stand on dry nonconductive surfaces when working on live circuits and using electric tools

K. Check all circuits for voltage before doing any service work

L. Tag and lock all electrical disconnects when working on live circuits

M. Have a ground on all power tools

N. Use proper size electrical cord

O. All tools should have proper guards

P. Do not use tools with frayed or damaged cords

Q. Wear eye protection

R. Do not touch moving parts

S. Mechanically ground all electric motors

III. Magnetism (Transparency 1)

A. Poles

1. North

2. South

B. Pole movement

1. Like poles repel

2. Unlike poles attract

INFORMATION SHEET

- C. Electromagnet
    - 1. Insulated wire wound around a soft iron core
    - 2. Alternating direction of current flow reverses polarity
    - 3. Essential in supplying the magnetic field for rotor rotation

IV. Magnets in an induction type motor (Transparency 2)

- A. Stator

    (NOTE: The stator becomes an electromagnet which reverses polarity 120 times a second on 60 Hz current.)

    - 1. Laminated soft iron
    - 2. Wound with insulated wire

        (NOTE: This wire is referred to as magnetic wire and it has a thin baked-on enamel coating.)

- B. Rotor
    - 1. A permanent magnet
    - 2. Turns seeking an opposite pole
    - 3. Push-pull action of attracting and repelling keeps rotor turning
    - 4. Automatically adjusts to the synchronous speed

V. Types of single-phase motors

- A. Split-phase
- B. Shaded-pole
- C. Capacitor start induction run (C.S.I.R.)
- D. Capacitor start capacitor run (C.S.R.)
- E. Permanent split capacitor (P.S.C.)
- F. Repulsion-induction

    (NOTE: This type of motor is becoming uncommon.)

INFORMATION SHEET

VI. Parts of open drive motor (Transparency 3)

- A. Stator assembly
  - 1. Stator windings
  - 2. Frame (motor body)
- B. Rotor
- C. End bells
- D. Overload
- E. Centrifugal control
- F. Starting switch
- G. Assembly bolts

VII. Common types of motor mounts (Transparency 4)

- A. Cradle mount
- B. Blower frame mount
- C. Three ring mount
- D. Lug ring mount
- E. Rigid mount

VIII. Motor enclosures

- A. Open
  - 1. Air openings in frame and/or end bells
  - 2. Used where dirt, dust, and moisture are not a problem
- B. Open-drip proof
  - 1. Air openings are in frame with shrouds to prevent moisture from entering
  - 2. Used where dripping moisture may be a problem
- C. Totally enclosed

  (NOTE: This is not a sealed motor.)

  - 1. No air openings
  - 2. Used where dust or dirt may be a problem

INFORMATION SHEET

D. Explosion proof

1. Constructed so that no sparking occurs
2. Used where explosive vapors are a problem

E. Submersible

1. Totally enclosed and sealed
2. Used where it is necessary for the motor to be submersed in water or some other fluid

IX. Three-phase motors (Transparency 5)

A. No starting devices

B. Each phase has a set of stator poles

(NOTE: Motor speed is determined by the number of pole pairs.)

C. Able to start heavy loads

X. Information provided on motor data plate (Transparency 6)

(NOTE: Never remove the data plate from a motor.)

A. Model number

B. Serial number

C. Type

D. Horsepower rating (Hp.)

E. Phase (Ph.)

(NOTE: This refers to single-phase or three-phase current.)

F. Hertz (cycle)

G. Voltage

H. Full load amperage (F.L.A.)

I. Locked rotor amperage (L.R.A.)

J. Service factor (S.F.)

Example: An S.F. of 1.15 means a motor can be loaded 15% greater than its rated horsepower.)

INFORMATION SHEET

K. R.P.M.

(NOTE: This is the revolutions per minute that a motor shaft will turn.)

L. Frame

(NOTE: This will be NEMA designated number indicating that the body of the motor is of a certain size.)

M. Temperature rise

(NOTE: This is the allowable motor temperature increase and is usually indicated in degrees Celsius (°C).)

N. Duty rating

XI. Types of motor V-pulleys (sheaves) (Transparency 7)

A. Standard pulley

B. Step pulley

C. Adjustable pulley

XII. Methods of determining pulley size

A. Pulley selection chart (Table 1)

(NOTE: This chart will only work with a 1725 r.p.m. motor.)

1. Select motor pulley size from left hand column

   (NOTE: If motor is less than 1/2 hp., motor pulley should not be less than 2 inches for the least belt slippage. If motor is 1/2 hp. or larger, the pulley should not be less than 3 inches.)

2. Move across to the right and locate speed that equipment is to operate

3. Reading straight up will give equipment pulley size

INFORMATION SHEET

Diam. Motor Pulley (inches)	Diameter of Pulley on Equipment (inches) Equipment Speed (RPM)														
	1 1/4	1 1/2	1 3/4	2	2 1/4	2 1/2	3	4	5	6 1/2	8	10	12	15	18
1 1/4	1725	1435	1230	1075	950	850	715	540	430	330	265	215	—	—	—
1 1/2	2075	1725	1475	1290	1140	1030	850	645	515	395	320	265	215	—	—
1 3/4	2400	2000	1725	1500	1340	1200	1000	750	600	460	375	315	250	200	—
2	2775	2290	1970	1725	1530	1375	1145	850	685	530	430	345	285	230	—
2 1/4	3100	2580	2200	1930	1725	1550	1290	965	775	595	485	385	325	255	215
2 1/2	3450	2870	2460	2150	1900	1725	1435	1075	850	660	540	430	355	285	240
3	4140	3450	2950	2580	2290	2070	1725	1290	1070	800	615	515	430	345	285
4	5500	4575	3950	3450	3060	2775	2295	1725	1375	1060	860	700	575	460	375
5	6850	5750	4920	4300	3825	3450	2865	2150	1725	1325	1075	860	715	575	475
6 1/2	8950	7475	6400	5600	4975	4480	3730	2790	2240	1725	1400	1120	930	745	620
8	—	9200	7870	6900	6125	5520	4600	3450	2750	2120	1725	1375	1140	915	765
10	—	—	9850	8620	7670	6900	5750	4300	3450	2650	2150	1725	1430	1140	950
12	—	—	—	—	9200	8280	6900	5160	4130	3180	2580	2075	1725	1375	1140
15	—	—	—	—	—	—	8635	6470	5170	3970	3230	2580	2150	1725	1425
18	—	—	—	—	—	—	—	7750	6200	4770	3880	3100	2580	2070	1725

TABLE 1

B. Pulley selection formula

1. RPM of motor pulley x diameter of motor pulley = RPM of equipment pulley x diameter of equipment pulley

2. Choose diameter of either pulley

3. Use formula and find diameter of other pulley

Example: Assume motor speed is 1725 RPM and equipment speed needs to be 2100 RPM, with a 3" motor pulley

1725 x 3 = 2100 x Diameter

$$\text{Diameter of equipment pulley} = \frac{1725 \times 3}{2100}$$

Diameter of equipment pulley = 2.46 inches

2.46 would read off to 2 1/2" pulley

XIII. Motor problems and causes

A. Failure to start

1. Blown fuse or open circuit breaker

2. Low voltage or no voltage

3. Open wiring circuit

INFORMATION SHEET

4. Incorrect power line connections
5. Excessive load
6. Excessive end play
7. Seized or worn bearings
8. Open overload

B. Excessive noise

1. Unbalance
2. Bent shaft
3. Loose parts
4. Faulty alignment
5. Worn bearings
6. Dirt in air gap between rotor and stator
7. Uneven air gap

C. Overheating of bearings

1. Motor bearings need oil
2. Dirty oil
3. Oil not reaching shaft
4. Excessive grease or oil
5. Excessive belt tension
6. Rough bearing surface
7. Bent shaft
8. Misalignment of shaft and bearing
9. Excessive end thrust
10. Excessive side pull
11. Belt slippage

INFORMATION SHEET

D. Overheating of motor
    1. Obstruction of ventilating system
    2. Overloading
    3. Rotor dragging on stator
    4. Incorrect voltage
    5. High ambient location

E. Rotor or stator burned out
    1. Worn bearings
    2. Moisture
    3. Acids or alkalies
    4. Accumulation of excessive conductive dust
    5. Overloading
    6. Defective start mechanism

XIV. Motor problems and remedies

A. Failure to start
    1. Replace or reset fuse
    2. Check supply voltage with motor underload

       (NOTE: Supply voltage should be within 10% of motor data plate voltage.)
    3. Check motor wiring with ohmmeter
    4. Remove load from motor and try to start
    5. Move motor shaft by hand to check for:
        a. End play
        b. Side play
        c. Bearing tightness

B. Excessive noise
    1. Replace out-of-balance pulley
    2. Remove pulley and check straightness of shaft

INFORMATION SHEET

3. Tighten motor accessories and mounting
4. Align drive pulley with driven pulley
5. Replace bearings
6. Clean motor
7. Check for out-of-round rotor

C. Overheating of bearings

1. Use recommended nondetergent motor bearing oil
2. Put clean oil in reservoir

   (NOTE: This will only be possible on large motors with bearing oil reservoirs.)

3. Clean excessive grease build up from ball bearings
4. Adjust belt to proper tension and check with an ammeter
5. Move motor shaft by hand to check for:
   a. End play
   b. Side play
   c. Bearing tightness
6. Replace rough or worn bearings
7. Remove pulley and check for bent shaft
8. Align drive pulley with driven pulley

D. Overheating of motor

1. Clean motor
2. Check belt tension and adjust
3. Check full load amperage
4. Check for correct voltage

   (NOTE: This voltage check should be made with the motor underload and at the motor terminals.)

5. Check for loose bearings

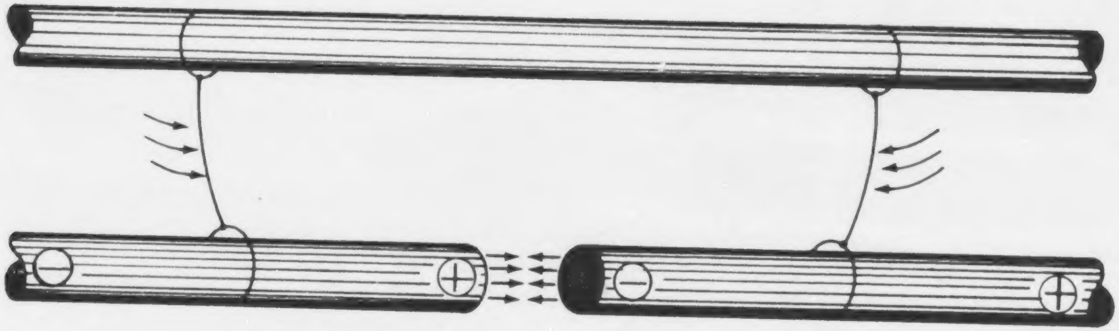
INFORMATION SHEET

6. Check for tight bearings
7. Check pulley alignment
8. Remove pulley and check for bent shaft

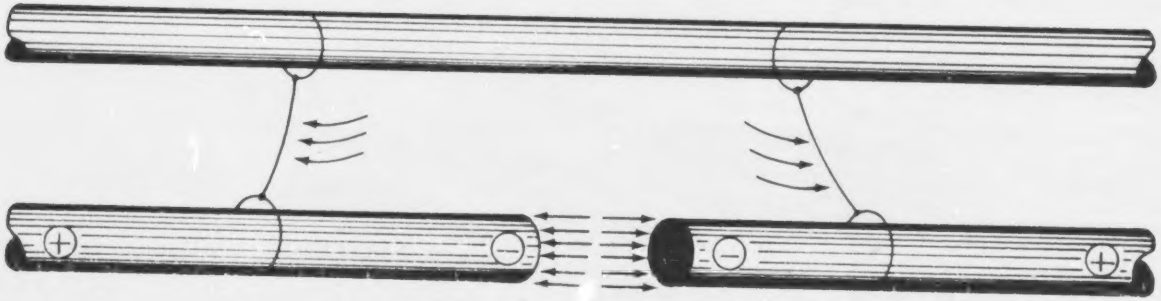
E. Rotor or stator burned out

1. Have stator rewound
2. Replace rotor
3. Replace complete motor

Attraction And Repulsion Of Charges

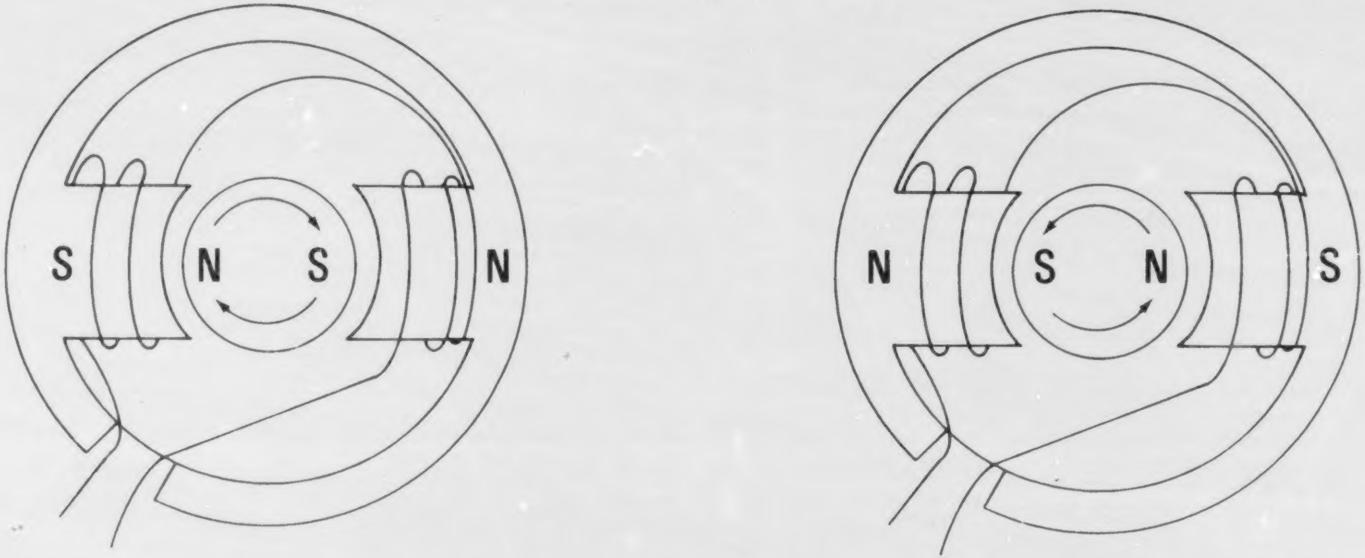


⊕ ⊖ Charges Attract



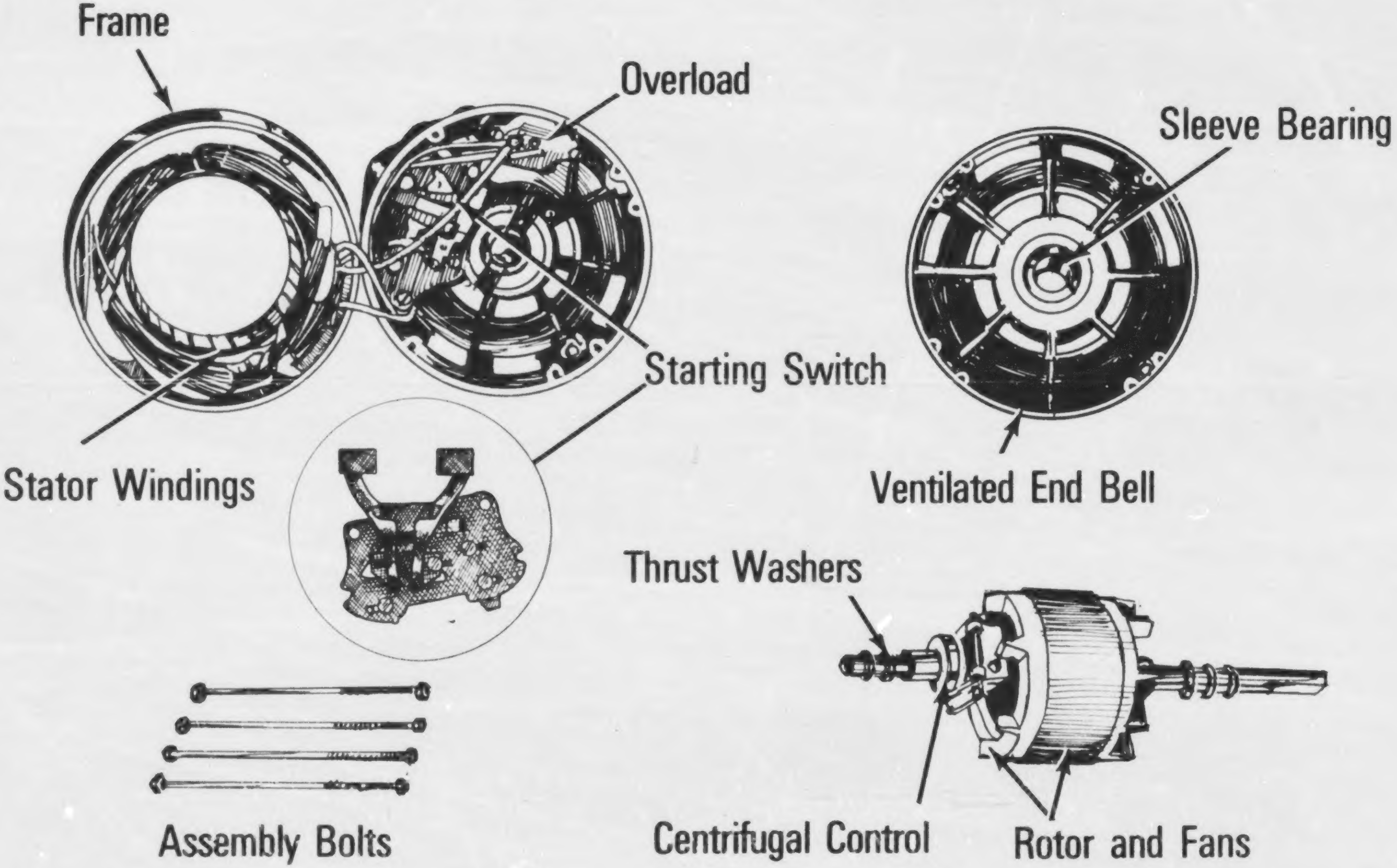
⊕ ⊕ Or ⊖ ⊖ Charges Repel

Electric Motor

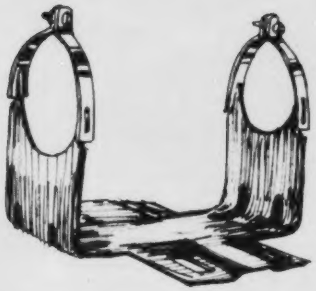


Reversing Direction Of Current Flow Reverses Magnetic Polarity

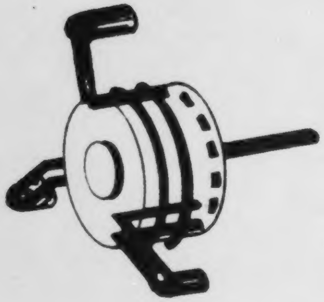
Parts Of An Open Drive Motor


Frame
Overload
Sleeve Bearing
Starting Switch
Stator Windings
Ventilated End Bell
Thrust Washers
Assembly Bolts
Centrifugal Control
Rotor and Fans

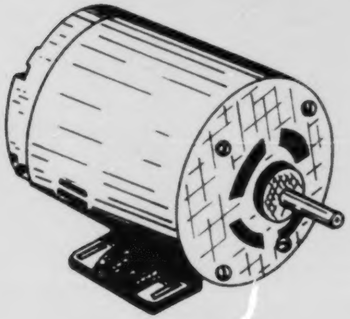
Types Of Motor Mounts



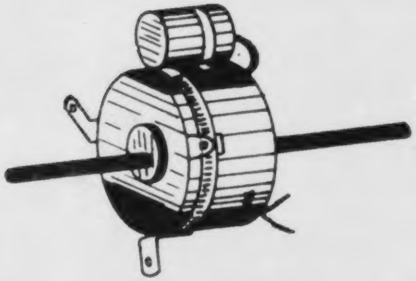
Cradle



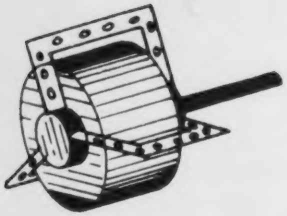
Three Ring



Rigid Mount

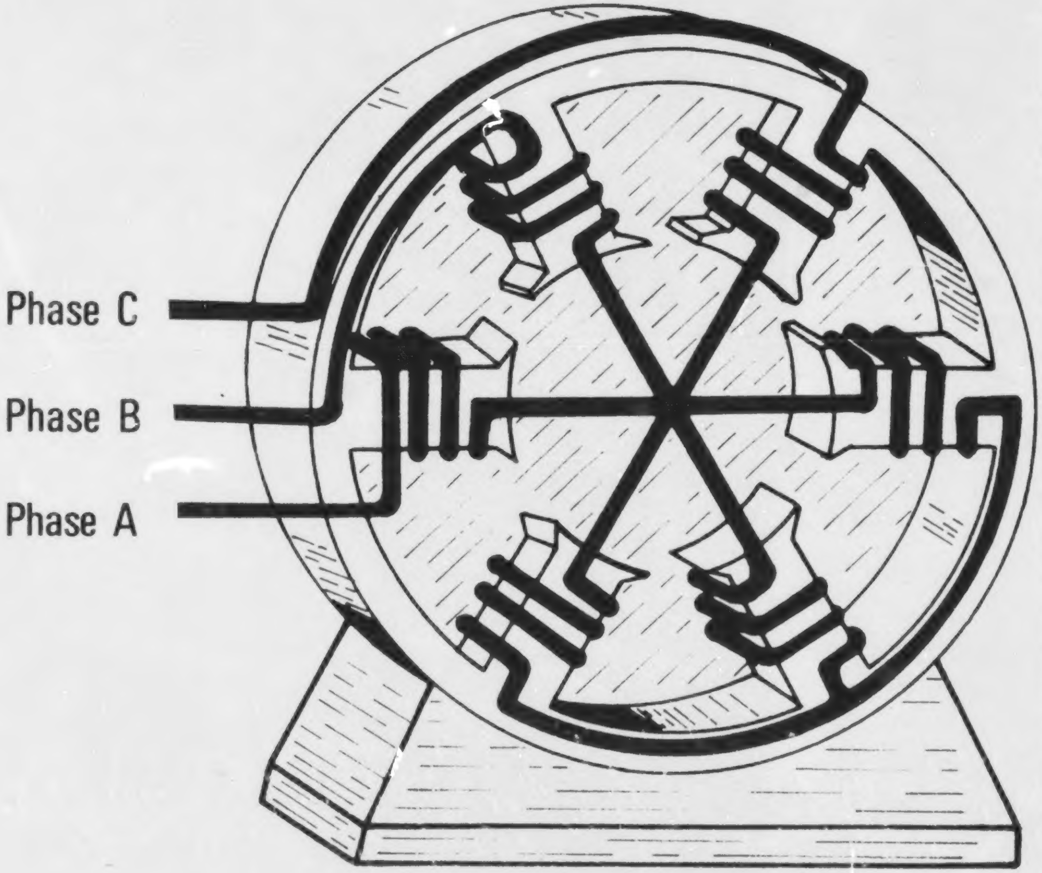


Lug Ring

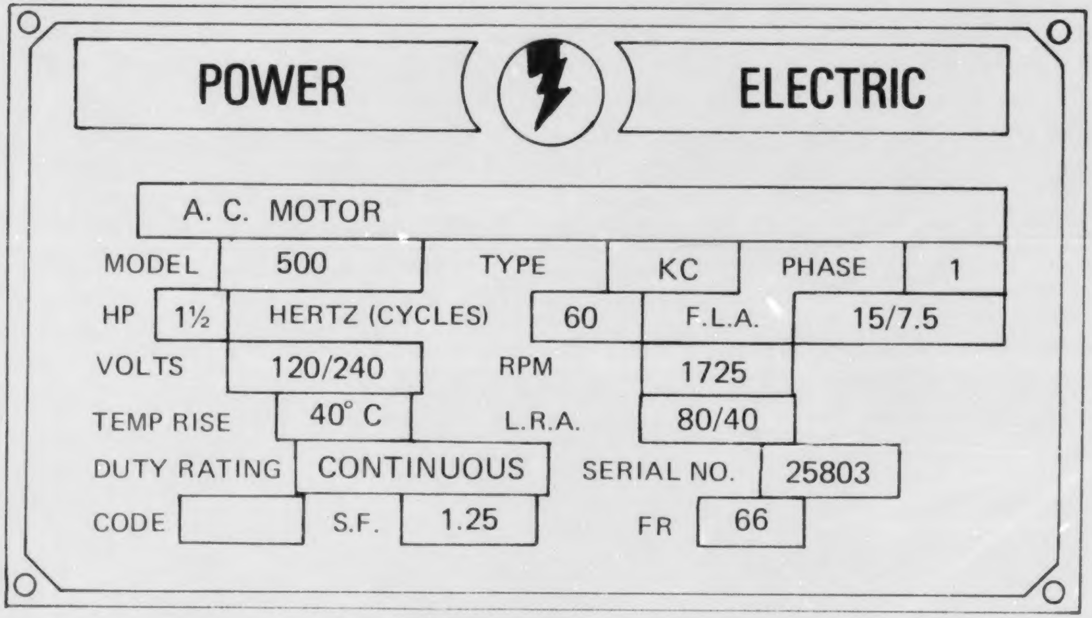


Blower Frame

Three-Phase Motor


Phase C
Phase B
Phase A

Motor Data Plate



POWER **ELECTRIC**

A. C. MOTOR

MODEL 500 TYPE KC PHASE 1

HP 1½ HERTZ (CYCLES) 60 F.L.A. 15/7.5

VOLTS 120/240 RPM 1725

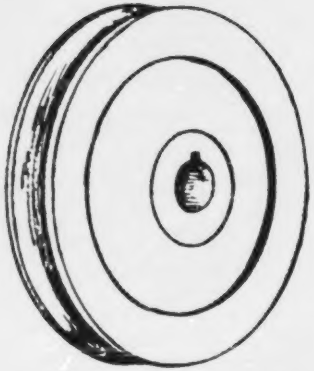
TEMP RISE 40° C L.R.A. 80/40

DUTY RATING CONTINUOUS SERIAL NO. 25803

CODE S.F. 1.25 FR 66

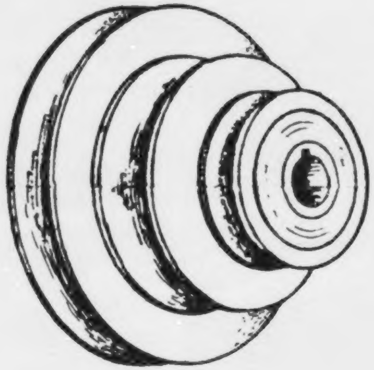
Types of Motor V-Pulleys

(SHEAVES)

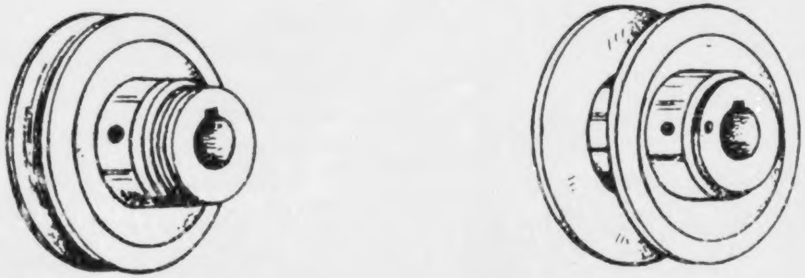


Standard Pulley

V-Step Pulley



Adjustable V-Pulley



Closed

Open

INTRODUCTION TO ELECTRIC MOTORS
UNIT I

ASSIGNMENT SHEET #1--GIVE THE REMEDY TO MOTOR PROBLEMS

In the following situations the problems and the causes are stated; give the remedy (or remedies) for each situation.

1. Motor fails to start and an open circuit breaker was found to be the cause.

2. Motor is overheating and the ventilation openings in the end bells were found to be clogged.

3. Motor is excessively noisy due to worn bearings.

ASSIGNMENT SHEET #1

4. Motor bearings are overheating due to excessive belt tension.

5. Motor is overheating due to being overloaded.

INTRODUCTION TO ELECTRIC MOTORS
UNIT I

ANSWERS TO ASSIGNMENT SHEET

1. Reset breaker or replace fuse.
2. Electric motors must be kept clean and dry, necessitating periodic inspections. Dust is removed, and ventilating openings must not be covered by other obstructions.
3. A dry or slightly worn bearing results in slip frequency noise or purr. Oil the bearings properly (periodically as required) or replace.
4. Adjust belt tension to proper value and check with ammeter.
5. Check driven device to make sure it does not bind. Check application by measuring input watts and amps under normal operating conditions.

INTRODUCTION TO ELECTRIC MOTORS
UNIT I

JOB SHEET #1--DETERMINE LENGTH OF A V-BELT

I. Tools and materials

  A. Flexible tape measure

  B. Belt driven equipment

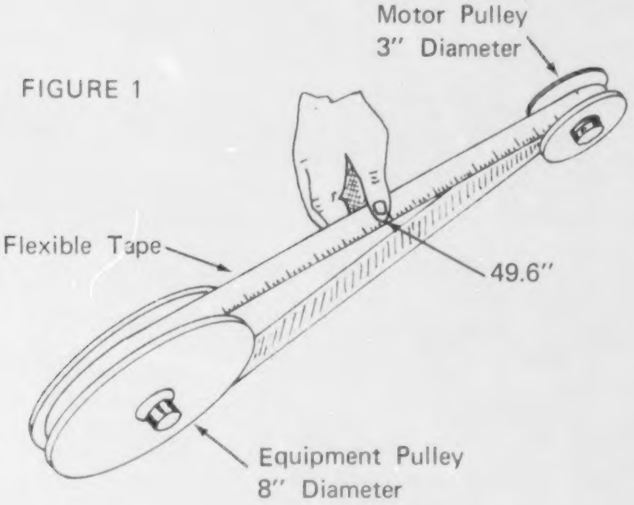
II. Procedure

  A. Disconnect electric power from belt driven equipment

  B. Wrap flexible tape around pulleys (Figure 1)

  (NOTE: Be sure that the tape measure fits in the pulley groove at the same place the belt will fit.)

FIGURE 1


Motor Pulley
3" Diameter
Flexible Tape
49.6"
Equipment Pulley
8" Diameter

  C. Round the measurement off to the nearest full inch

  D. Check that the motor is in the center of its adjustment range

  E. Have instructor check

  F. Clean up and put away tools

INTRODUCTION TO ELECTRIC MOTORS
UNIT I

JOB SHEET #2--ADJUST V-BELT TENSION

I. Tools and materials

   A. Open end wrenches

   B. Straight edge

   C. Ammeter

   D. Belt driven equipment

II. Procedure

   A. Disconnect electric power from belt driven equipment

   B. Remove V-belt

   C. Check pulley alignment (Figure 1)

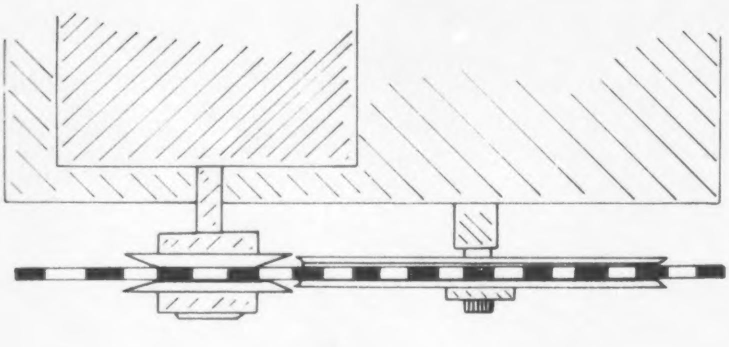


FIGURE 1

   D. Place a straight edge in the pulley grooves to check alignment

   (NOTE: If pulleys do not align, loosen set screws and align them.)

   E. Replace belt

JOB SHEET #2

F. Press down on belt halfway between motor pulley and blower pulley (Figure 2)

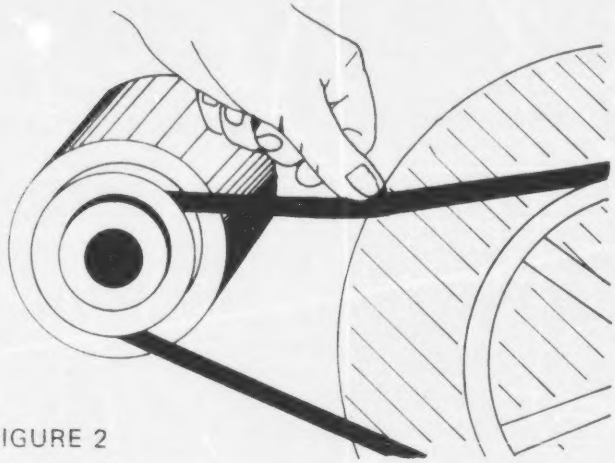


FIGURE 2

G. Check for a deflection of 3/4" to 1"

(NOTE: Another method of checking belt deflection is with the use of a tension gauge. See Figure 3. When using this type of gauge refer to the manufacturer's recommendations for proper tension.)

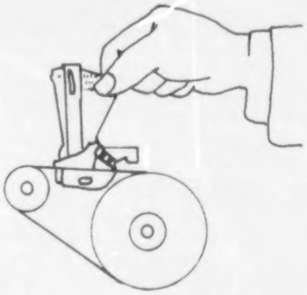


FIGURE 3

H. If belt is too loose, loosen motor adjustment and tighten belt

I. Recheck deflection

J. Replace any blower panels that have been removed

(NOTE: In order to obtain an accurate amperage reading, the panels must be on the blower compartment.)

K. Start the blower

JOB SHEET #2

L. Check amperage

(NOTE: If the amperage draw is too high, the belt is too tight.)

M. Have instructor check

N. Stop blower

O. Clean up and put away tools

INTRODUCTION TO ELECTRIC MOTORS
UNIT I

NAME____________________________

TEST

1. Match the terms on the right to the correct definitions.

_____a. Stationary section that consists of the windings and core which form the electromagnet that produces the magnetic field causing the motor to turn

_____b. Alternating current motor in which the stator is connected to the power source; this induces current into a secondary winding called the rotor

_____c. Soft iron, laminated portion of the stator which the insulated wire is wound around

_____d. Single-phase motor which incorporates a commutator and brushes

_____e. Rotating section which rotates within the stator of a motor

_____f. Constant speed to which an alternating current motor adjusts itself, depending on the frequency of the power supply and the number of poles in the motor

_____g. Establishes certain voluntary standards relating to motors

_____h. Deviation from a standard

_____i. Difference between the synchronous speed of a motor and the speed at which it operates

_____j. Rubber support on each end of the motor which cushions the motor base from vibrations

_____k. Mounting brackets are permanently attached to the motor frame

_____l. A low resistance conductor which connects two parts of a circuit in parallel

1. Rotor
2. Poles
3. Induction motor
4. Synchronous speed
5. Repulsion motor
6. Stator
7. Deflection
8. NEMA (National Electrical Manufacturer's Association)
9. Slip
10. Resilient mount
11. Rigid mount
12. Shunt

2. List ten safety rules pertaining to working with electric motors.

   a.

   b.

   c.

   d.

   e.

   f.

   g.

   h.

   i.

   j.

3. Discuss magnetism.

4. Discuss magnets in an induction type motor.

5. List five types of single-phase motors.

   a.

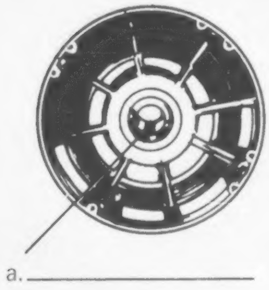
   b.

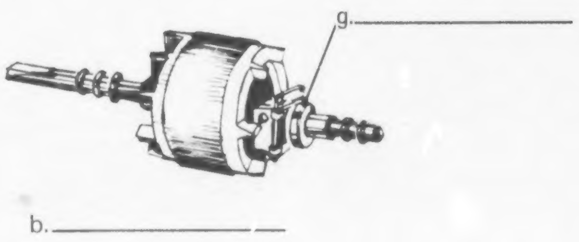
   c.

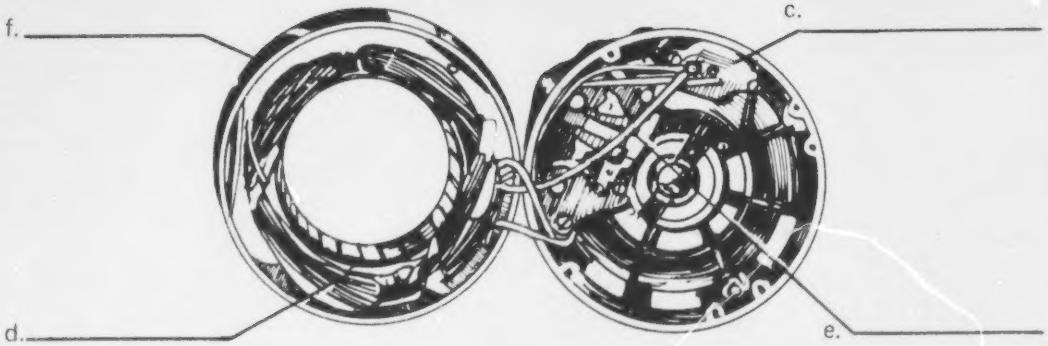
   d.

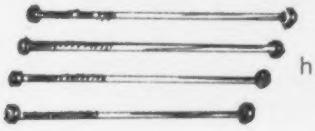
   e.

6. Identify the parts of an open drive motor.



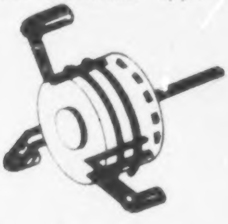




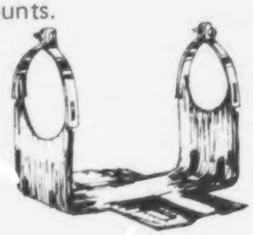


h. ____________________

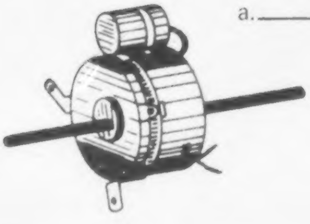
7. Identify the common types of motor mounts.



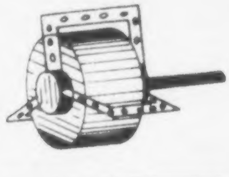
a. ____________________



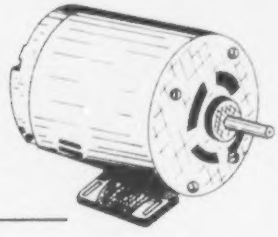
b. ____________________



c. ____________________



d. ____________________



e. ____________________

8. Discuss motor enclosures.

a. Open

b. Open-drip proof

c. Totally enclosed

d. Explosion proof

e. Submersible

9. Discuss three-phase motors.

10. List the fourteen items of information provided on a motor data plate.

a.

b.

c.

d.

e.

f.

g.

h.

i.

j.

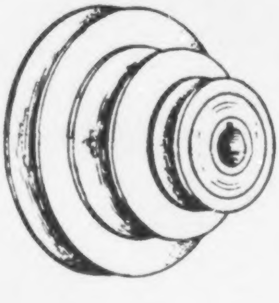
k.

l.

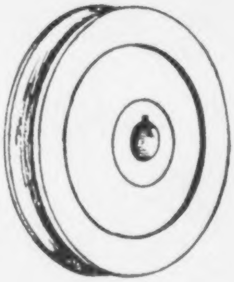
m.

n.

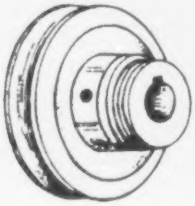
11. Identify the types of motor V-pulleys.



a. ______________________



b. ______________________



c. ______________________

12. Solve the problems using the pulley selection chart method for determining pulley size.

Diam. Motor Pulley (inches)	Diameter of Pulley on Equipment (inches) Equipment Speed (RPM)														
	1 1/4	1 1/2	1 3/4	2	2 1/4	2 1/2	3	4	5	6 1/2	8	10	12	15	18
1 1/4	1725	1435	1230	1075	950	850	715	540	430	330	265	215	—	—	—
1 1/2	2075	1725	1475	1290	1140	1030	850	645	515	395	320	265	215	—	—
1 3/4	2400	2000	1725	1500	1340	1200	1000	750	600	460	375	315	250	200	—
2	2775	2290	1970	1725	1530	1375	1145	850	685	530	430	345	285	230	—
2 1/4	3100	2580	2200	1930	1725	1550	1290	965	775	595	485	385	325	255	215
2 1/2	3450	2870	2460	2150	1900	1725	1435	1075	850	660	540	430	355	285	240
3	4140	3450	2950	2580	2290	2070	1725	1290	1070	800	615	515	430	345	285

a. Equipment speed 750 RPM
Motor pulley 1 3/4"
Equipment pulley ____________

b. Motor pulley 2"
Equipment pulley 3"
Equipment speed ____________

c. Equipment speed 1725 RPM
Equipment pulley 1 1/4"
Motor pulley ____________

d. Motor pulley 3"
Equipment speed 2580 RPM
Equipment pulley ____________

e. Equipment pulley 5"
Motor pulley 3"
Equipment speed ____________

13. List three causes for each of the following motor problems.

a. Failure to start

1)

2)

3)

b. Excessive noise

1)

2)

3)

c. Overheating of bearings

1)

2)

3)

d. Overheating of motor

1)

2)

3)

e. Rotor or stator burned out

1)

2)

3)

14. List three remedies for each of the following motor problems.

a. Failure to start

1)

2)

3)

b. Excessive noise

1)

2)

3)

c. Overheating of bearings

1)

2)

3)

d. Overheating of motor

 1)

 2)

 3)

e. Rotor or stator burned out

 1)

 2)

 3)

15. Demonstrate the ability to:

 a. Determine length of a V-belt.

 b. Adjust V-belt tension.

(NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

INTRODUCTION TO ELECTRIC MOTORS
UNIT I

ANSWERS TO TEST

1. a. 6
   b. 3
   c. 2
   d. 5
   e. 1
   f. 4
   g. 8
   h. 7
   i. 9
   j. 10
   k. 11
   l. 12

2. Any ten of the following:
   a. Don't underestimate the potential danger of a 110 VAC circuit
   b. Be careful around electric arcs because they will cause bad burns to skin and eyes
   c. Remember that involuntary reaction to electric shock can cause you to injure yourself and possibly others
   d. Do not work on live circuits except when absolutely necessary
   e. Never install equipment that will overload a circuit
   f. Never bypass electrical protective devices
   g. All electrical lines must be properly fused
   h. Protect all electrical wires when routing them over refrigerant tubing
   i. All electrical wiring must be well insulated
   j. Stand on dry nonconductive surfaces when working on live circuits and using electric tools
   k. Check all circuits for voltage before doing any service work
   l. Tag and lock all electrical disconnects when working on live circuits
   m. Have a ground on all power tools
   n. Use proper size electrical cord
   o. All tools should have proper guards
   p. Do not use tools with frayed or damaged cords

- q. Wear eye protection
- r. Do not touch moving parts
- s. Mechanically ground all electric motors

3. Discussion should include:
   - a. Poles
     - 1) North
     - 2) South
   - b. Pole movement
     - 1) Like poles repel
     - 2) Unlike poles attract
   - c. Electromagnet
     - 1) Insulated wire wound around a soft iron core
     - 2) Alternating direction of current flow reverses polarity
     - 3) Essential in supplying the magnetic field for rotor rotation
4. Discussion should include:
   - a. Stator
     - 1) Laminated soft iron
     - 2) Wound with insulated wire
   - b. Rotor
     - 1) A permanent magnet
     - 2) Turns seeking an opposite pole
     - 3) Push-pull action of attracting and repelling keeps rotor turning
     - 4) Automatically adjusts to the synchronous speed
5. Any five of the following:
   - a. Split-phase
   - b. Shaded-pole
   - c. Capacitor start induction run (C.S.I.R.)

- d. Capacitor start capacitor run (C.S.R.)
- e. Permanent split capacitor (P.S.C.)
- f. Repulsion-induction

6.
- a. End bell
- b. Rotor
- c. Overload
- d. Stator windings
- e. Starting switch
- f. Frame (motor body)
- g. Centrifugal control
- h. Assembly bolts

7.
- a. Three ring mount
- b. Cradle mount
- c. Lug ring mount
- d. Blower frame mount
- e. Rigid mount

8. Discussion should include:

- a. Open
  - 1) Air openings in frame and/or end bells
  - 2) Used where dirt, dust, and moisture are not a problem
- b. Open-drip proof
  - 1) Air openings are in frame with shrouds to prevent moisture from entering
  - 2) Used where dripping moisture may be a problem
- c. Totally enclosed
  - 1) No air openings
  - 2) Used where dust or dirt may be a problem

- d. Explosion proof
  - 1) Constructed so that no sparking occurs
  - 2) Used where explosive vapors are a problem
- e. Submersible
  - 1) Totally enclosed and sealed
  - 2) Used where it is necessary for the motor to be submersed in water or some other fluid

9. Discussion should include:
   - a. No starting devices
   - b. Each phase has a set of stator poles
   - c. Able to start heavy loads

10. a. Model number
   - b. Serial number
   - c. Type
   - d. Horsepower rating (Hp.)
   - e. Phase (Ph.)
   - f. Hertz (cycle)
   - g. Voltage
   - h. Full load amperage (F.L.A.)
   - i. Locked rotor amperage (L.R.A.)
   - j. Service factor (S.F.)
   - k. R.P.M.
   - l. Frame
   - m. Temperature rise
   - n. Duty rating

11. a. Step pulley
   - b. Standard pulley
   - c. Adjustable pulley

12. a. 4"
    b. 1145 RPM
    c. 1 1/4"
    d. 2"
    e. 1070 RPM

13. Any three of the following under each section:

    a. Failure to start
        1) Blown fuse or open circuit breaker
        2) Low voltage or no voltage
        3) Open wiring circuit
        4) Incorrect power line connections
        5) Excessive load
        6) Excessive end play
        7) Seized or worn bearings
        8) Open overload

    b. Excessive noise
        1) Unbalance
        2) Bent shaft
        3) Loose parts
        4) Faulty alignment
        5) Worn bearings
        6) Dirt in air gap between rotor and stator
        7) Uneven air gap

    c. Overheating of bearings
        1) Motor bearings need oil
        2) Dirty oil
        3) Oil not reaching shaft
        4) Excessive grease or oil
        5) Excessive belt tension

6) Rough bearing surface
7) Bent shaft
8) Misalignment of shaft and bearing
9) Excessive end thrust
10) Excessive side pull
11) Belt slippage

d. Overheating of motor
1) Obstruction of ventilating system
2) Overloading
3) Rotor dragging on stator
4) Incorrect voltage
5) High ambient location

e. Rotor or stator burned out
1) Worn bearings
2) Moisture
3) Acids or alkalies
4) Accumulation of excessive conductive dust
5) Overloading
6) Defective start mechanism

14. Any three of the following under each section:

a. Failure to start
1) Replace or reset fuse
2) Check supply voltage with motor underload
3) Check motor wiring with ohmmeter
4) Remove load from motor and try to start
5) Move motor shaft by hand to check for:
a) End play
b) Side play
c) Bearing tightness

b. Excessive noise
    1) Replace out-of-balance pulley
    2) Remove pulley and check straightness of shaft
    3) Tighten motor accessories and mounting
    4) Align drive pulley with driven pulley
    5) Replace bearings
    6) Clean motor
    7) Check for out-of-round rotor

c. Overheating of bearings
    1) Use recommended nondetergent motor bearing oil
    2) Put clean oil in reservoir
    3) Clean excessive grease build up from ball bearings
    4) Adjust belt to proper tension and check with an ammeter
    5) Move motor shaft by hand to check for:
        a) End play
        b) Side play
        c) Bearing tightness
    6) Replace rough or worn bearings
    7) Remove pulley and check for bent shaft
    8) Align drive pulley with driven pulley

d. Overheating of motor
    1) Clean motor
    2) Check belt tension and adjust
    3) Check full load amperage
    4) Check for correct voltage
    5) Check for loose bearings
    6) Check for tight bearings
    7) Check pulley alignment
    8) Remove pulley and check for bent shaft

e. Rotor or stator burned out

  1) Have stator rewound

  2) Replace rotor

  3) Replace complete motor

15. Performance skills evaluated to the satisfaction of the instructor

SPLIT-PHASE MOTORS
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify various components of split-phase motors and list windings and their characteristics. The student should also be able to match motor lead code number to color, wire a split-phase motor, and disassemble, inspect, clean, and reassemble a split-phase motor. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with split-phase motors to the correct definitions.
2. State the common horsepower range of split-phase motors.
3. List applications of split-phase motors.
4. List the two windings of a split-phase motor.
5. List the characteristics of the windings in a split-phase motor.
6. Discuss the purpose of the starting mechanism.
7. Identify the components of a split-phase motor.
8. Match start and run windings to the motor lead codes by NEMA.
9. Match code number to color code of motor leads.
10. Identify the directions of rotation.
11. Identify the motor power wirings.
12. Demonstrate the ability to:
    a. Wire a split-phase dual voltage motor to a 208/240 VAC supply.
    b. Disassemble, inspect, clean, and reassemble a split-phase motor.

SPLIT-PHASE MOTORS
UNIT II

SUGGESTED ACTIVITIES

I. Instructor:

- A. Provide student with objective sheet.
- B. Provide student with information and job sheets.
- C. Make transparencies.
- D. Discuss unit and specific objectives.
- E. Discuss information sheet.
- F. Demonstrate and discuss the procedures outlined in the job sheets.
- G. Disassemble a split-phase motor and place it on a display board.
- H. Give test.

II. Student:

- A. Read objective sheet.
- B. Study information sheet.
- C. Complete job sheets.
- D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

- A. Objective sheet
- B. Information sheet
- C. Transparency masters
    1. TM 1--Split-Phase Motors
    2. TM 2--Characteristics of Run and Start Windings

3. TM 3--Schematic Diagram of a Split-Phase Motor
4. TM 4--NEMA Motor Lead Color Code
5. TM 5--Motor Wiring for Rotations
6. TM 6--Motor Wiring for 120 VAC or 208/240 VAC Operation

D. Job sheets

1. Job Sheet #1--Wire a Split-Phase Motor to a 208/240 VAC Supply
2. Job Sheet #2--Disassemble, Inspect, Clean, and Reassemble a Split-Phase Motor

E. Test

F. Answers to test

II. References:

A. Schweitzer, Gerald. *Basics of Fractional Horsepower Motors and Repair.* Rochelle Park, New Jersey: Hayden Book Co., Inc., 1960.

B. Althouse, Andrew D.; Turnquist, Carl H.; and Bracciano, Alfred F. *Modern Refrigeration and Air Conditioning.* Homewood, Illinois: Goodheart-Willcox Co., 1975.

SPLIT-PHASE MOTORS
UNIT II

INFORMATION SHEET

I. Terms and definitions

   A. Torque--Twisting force created by a motor as it starts and runs

   B. Start winding--Winding in the electric motor that is used only briefly while the motor is starting

   C. Run winding--Winding of motor which has current flowing through it during normal operation of motor

   D. Split-phase motor--Motor with two stator windings; while both windings are in use for starting, the starting winding is disconnected by centrifugal switch after motor attains approximately 75 to 80% of its speed and motor then operates on run winding only

II. Common horsepower range of split-phase motors--1/20 to 3/4

III. Applications of split-phase motors (Transparency 1)

   A. Fans

   B. Oil burners

   C. Pumps

   D. Blowers

   E. Domestic refrigerator compressors

   (NOTE: All motor starting components must be external on a hermetic compressor motor.)

IV. Windings of split-phase motor

   A. Start

   B. Run

V. Characteristics of windings in split-phase motor (Transparency 2)

   A. Start winding

      1. High resistance

      2. Small wire

INFORMATION SHEET

3. More turns
4. Wound on top of run winding in pole slots

B. Run winding

1. Low resistance
2. Heavier wire
3. Fewer turns
4. Wound in bottom of pole slots

VI. Purpose of starting mechanism--Removes starting winding when motor reaches approximately 75 to 80% of its synchronous speed

VII. Components of split-phase motor (Transparency 3)

A. Overload (inherent motor protection)

B. Rotor

C. Centrifugal starting mechanism or relay

D. Starting winding

E. Run winding

VIII. National Electrical Manufacturer's Association (NEMA) motor lead codes for start and run windings (Transparency 4)

A. Start winding--T2 and T4

B. Run winding--T1 and T3

(NOTE: In older motors the run winding was marked M1 and M2, and the start winding was marked S1 and S2.)

IX. Motor lead color code

A. T1--Red

B. T2--Blue

C. T3--Yellow

D. T4--Black

(NOTE: This color coding is typical and may vary in some specific motors.)

INFORMATION SHEET

X. Directions of rotation (Transparency 5)

   A. Counterclockwise

   B. Clockwise

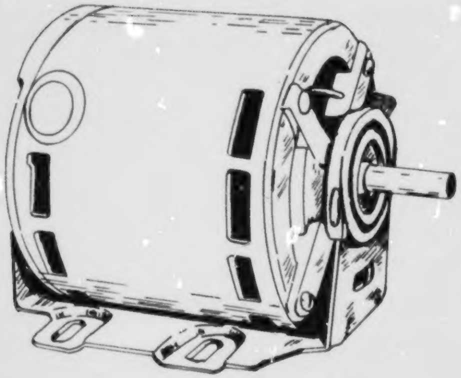
   (NOTE: Motor rotation is determined from shaft end on some motors and opposite the shaft end on others.)

XI. Motor power wiring (Transparency 6)

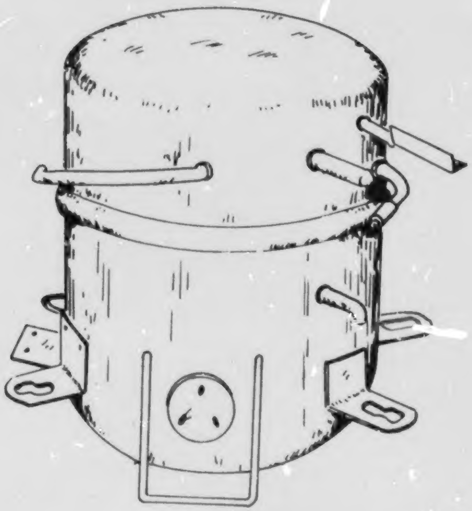
   A. 120 VAC

   B. 208/240 VAC

Split-Phase Motors



Open Drive Motor



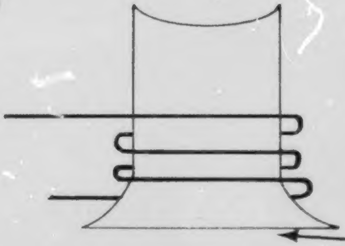
Hermetic Motor

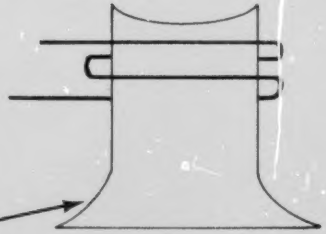
TM 1

ARC II - 67-C

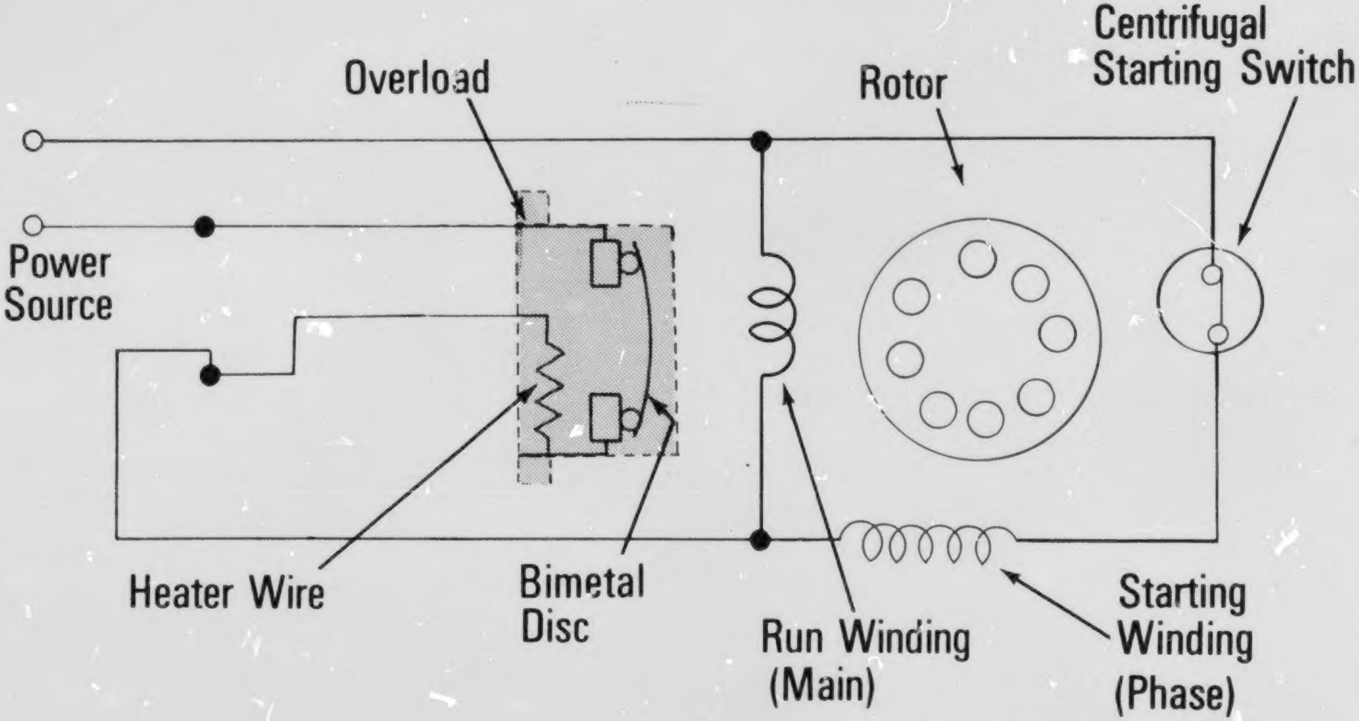
Characteristics of Run and Start Windings

Run	Start
Low Resistance	High Resistance
Heavier Wire	Lighter Wire
Few Turns	More Turns
Wound in Bottom of Slots	Wound on Top of Main Winding

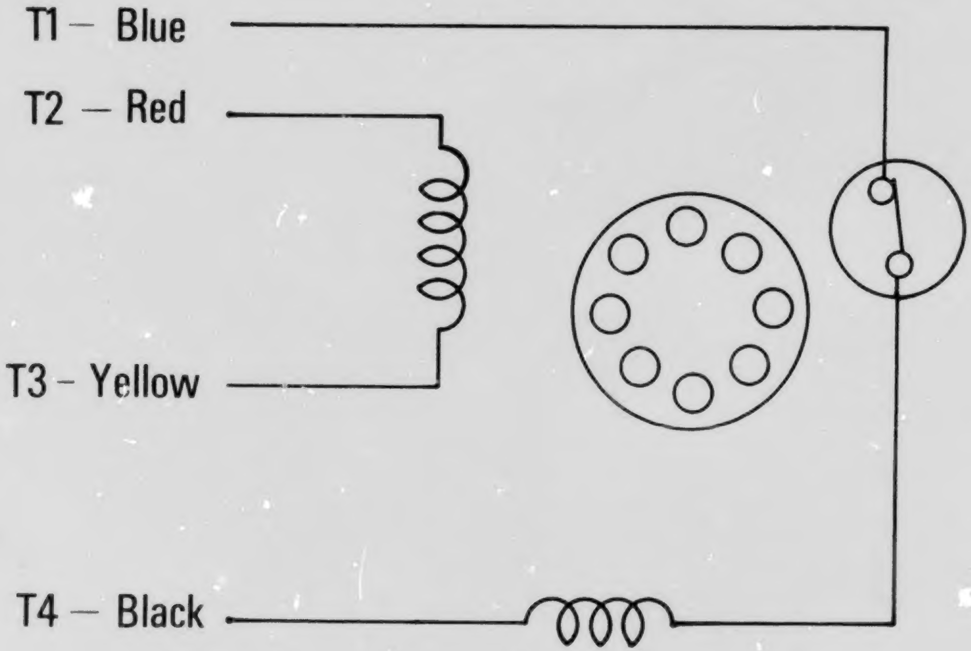




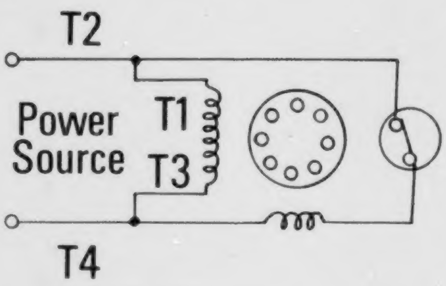
Schematic Diagram of a Split-Phase Motor


Overload
Rotor
Centrifugal Starting Switch
Power Source
Heater Wire
Bimetal Disc
Run Winding (Main)
Starting Winding (Phase)

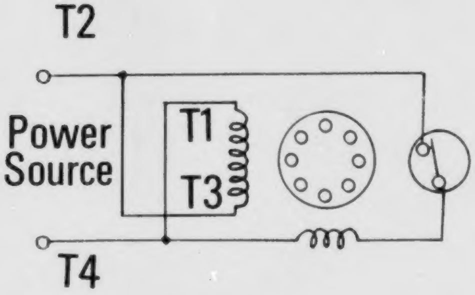
NEMA Motor Lead Color Code


T1 – Blue
T2 – Red
T3 – Yellow
T4 – Black

Motor Wiring for Rotations


T2
Power Source
T1
T3
T4

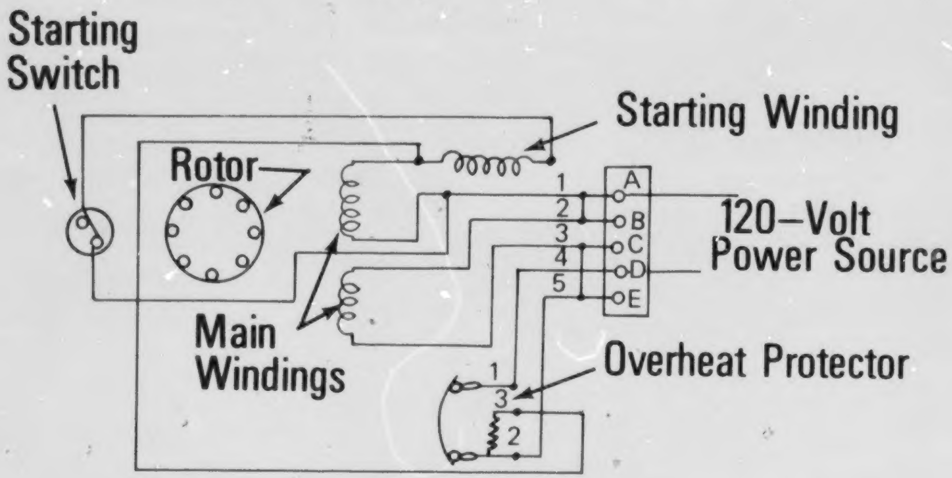
Counterclockwise Rotation

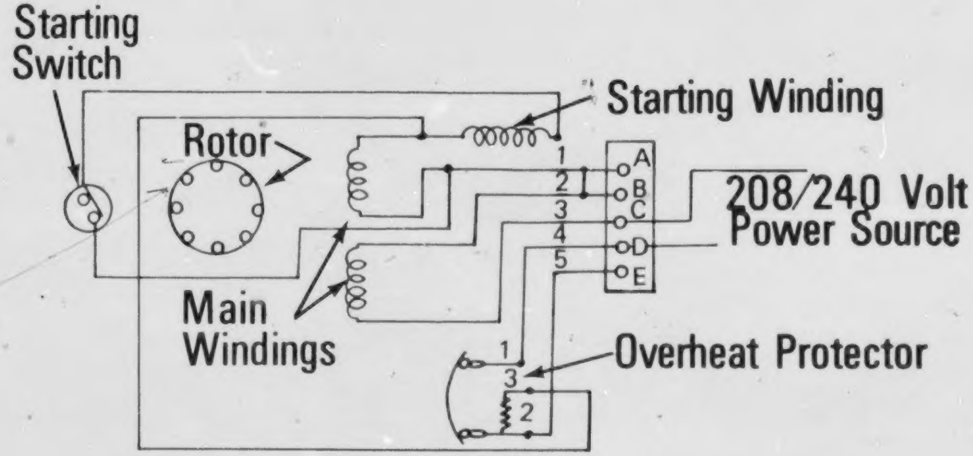

T2
Power Source
T1
T3
T4

Clockwise Rotation

(Note: On some motors the wiring is inaccessible.)

Motor Wiring for 120 VAC or 208/240 VAC Operation


Starting Switch
Starting Winding
Rotor
1
2
3
4
5
A
B
C
D
E
120–Volt Power Source
Main Windings
Overheat Protector
1
3
2


Starting Switch
Starting Winding
Rotor
1
2
3
4
5
A
B
C
D
E
208/240 Volt Power Source
Main Windings
Overheat Protector
1
3
2

SPLIT-PHASE MOTORS
UNIT II

JOB SHEET #1--WIRE A SPLIT-PHASE DUAL VOLTAGE MOTOR TO A 208/240 VAC SUPPLY

I. Tools and materials

- A. Ammeter
- B. Voltmeter
- C. Dual voltage split-phase motor

II. Procedure

- A. Check to be sure all electrical power is disconnected
- B. Connect lead #3 to L_1 (Figure 1)

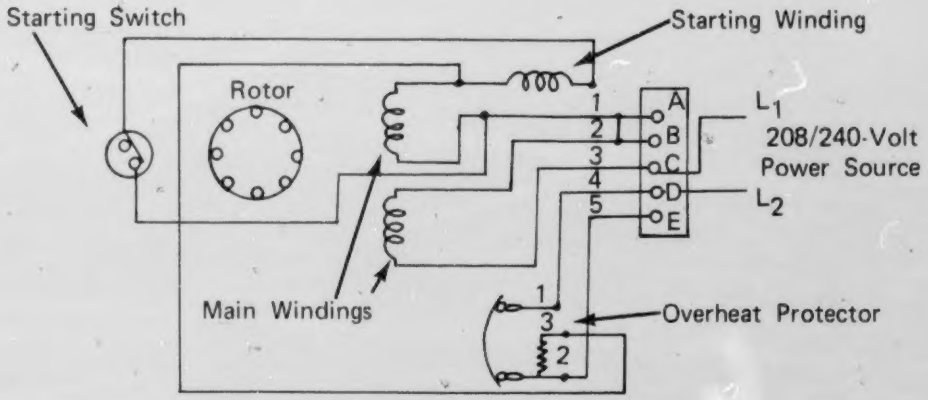

Starting Switch
Starting Winding
Rotor
1
2
3
4
5
A
B
C
D
E
L_1
208/240-Volt Power Source
L_2
Main Windings
Overheat Protector
1
3
2

FIGURE 1

- C. Connect leads #1 and #2 together
- D. Connect lead #4 to L_2
- E. Have instructor inspect wiring
- F. Place voltmeter at 250 VAC or higher range
- G. Clip voltmeter leads to motor leads #3 and #4
- H. Place ammeter in highest range
- I. Clamp ammeter around L_1 or L_2
- J. Turn on electrical power and start motor

JOB SHEET #1

K. Adjust test meters for most accurate reading

L. Record readings

M. Have instructor inspect

N. Clean up and put away tools

SPLIT-PHASE MOTORS
UNIT II

JOB SHEET #2--DISASSEMBLE, INSPECT, CLEAN, AND REASSEMBLE A SPLIT-PHASE MOTOR

I. Tools and materials

A. Split-phase motor

B. Screwdriver

C. Open end wrench

D. Center punch

E. Ball peen hammer

F. Soft face hammer

G. Small socket wrench set

H. Motor cleaning fluid

I. Clean shop towel

J. Compressed air

K. Safety glasses

L. Polishing cloth

II. Procedure

A. Check to be sure electrical power is disconnected

B. Remove motor from refrigeration system, if necessary

C. Clean off outer surface of motor

D. Disconnect wires at motor

(NOTE: Be sure to label or draw a diagram of wire positions on motor terminals.)

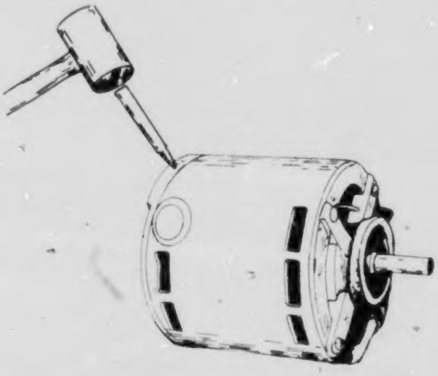
E. Remove motor pulley

JOB SHEET #2

F. Mark end bells (Figure 1)

(NOTE: This is to keep bell ends in their proper places. Using center punch, place one mark on pulley end bell and two marks on opposite end bell; mark housing in the same way.)

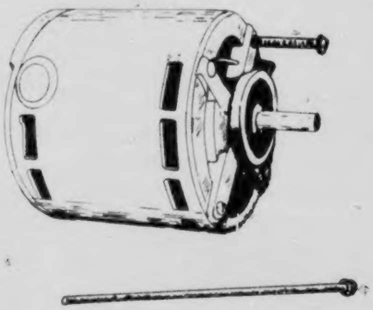
FIGURE 1



G. Remove bolts holding end bells (Figure 2)

(NOTE: Prior to removing end bells polish shaft ends for easy removal.)

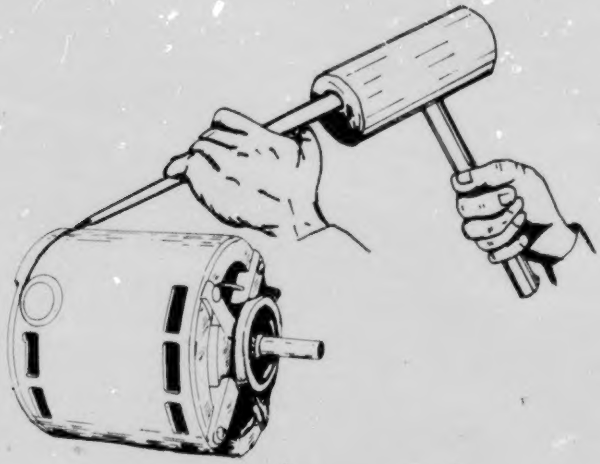
FIGURE 2



JOB SHEET #2

H. Use soft-faced hammer and drift punch to tap end bells loose (Figure 3)

FIGURE 3



I. Remove end bell that does not contain starting switch

(NOTE: Observe position and number of shims as you remove the rotor.)

J. Remove rotor

K. Remove end bell containing starting switch

(CAUTION: Do not attempt to remove stator.)

L. Put on safety glasses

M. Clean motor with compressed air

N. Clean outside of motor with special cleaning fluid

O. Clean bearings and make sure wicking is in place and oiled

(CAUTION: Do not clean ball bearings with compressed air.)

P. Replace end bell containing switch

Q. Insert rotor making sure shims are in place

(NOTE: A drop of oil should be placed on bearing part of the shaft.)

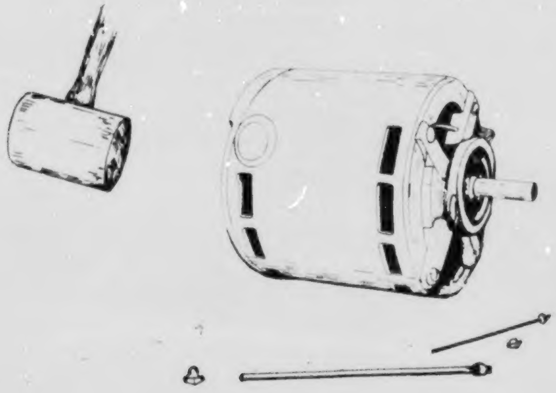
R. Visually inspect rotor and stator alignment

S. Check position of end bells with center punch marks

JOB SHEET #2

T. Use soft-faced hammer to tap end bells in place (Figure 4)

FIGURE 4



U. Insert end bell bolts and tighten

V. Turn shaft by hand

(NOTE: If it is tight, end bells may not be in proper alignment, or the wicking may be between bearing and shaft.)

W. Have instructor inspect

X. Connect temporary leads and test motor

Y. Clean up and put away tools

SPLIT-PHASE MOTORS
UNIT II

NAME ______________________

TEST

1. Match the terms on the right to the correct definitions.

_____a. Twisting force created by a motor as it starts and runs

_____b. Winding of motor which has current flowing through it during normal operation of motor

_____c. Motor with two stator windings; while both windings are in use for starting, the starting winding is disconnected by centrifugal switch after motor attains approximately 75 to 80% of its speed, and motor then operates on run winding only

_____d. Winding in the electric motor that is used only briefly while the motor is starting

1. Split-phase motor
2. Start winding
3. Run winding
4. Torque

2. State the common horsepower range of split-phase motors.

3. List four applications of split-phase motors.

a.

b.

c.

d.

4. List the two windings of a split-phase motor.

a.

b.

5. List the characteristics of the windings in a split-phase motor.

   a. Start winding

      1)

      2)

      3)

      4)

   b. Run winding

      1)

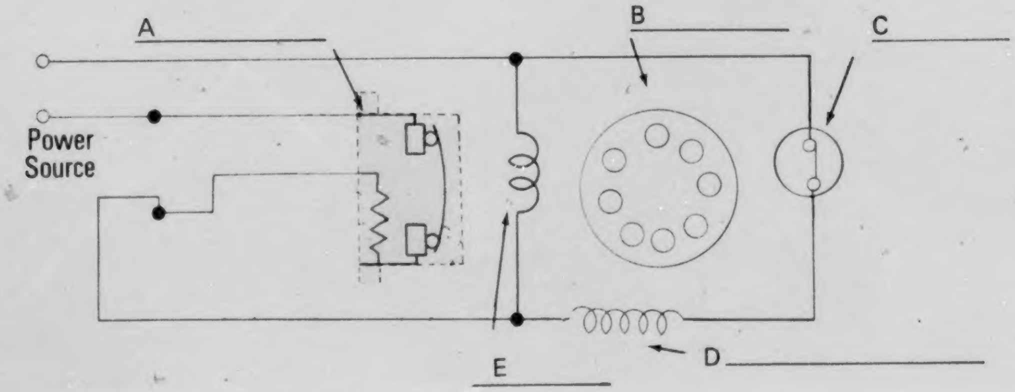
      2)

      3)

      4)

6. Discuss the purpose of the starting mechanism.

7. Identify the components of a split-phase motor.



8. Match start and run windings on the right to the motor lead codes by NEMA.

______a. T1

______b. T2

______c. T3

______d. T4

1. Start winding
2. Run winding

9. Match the code numbers on the right to the code colors of motor leads.

______a. Yellow

______b. Red

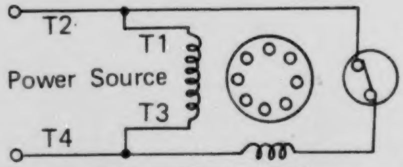
______c. Black

______d. Blue

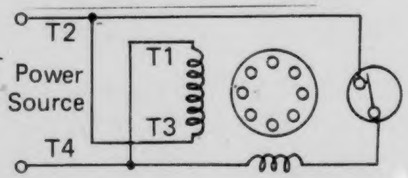
1. T3
2. T1
3. T2
4. T4

10. Identify the directions of rotation.

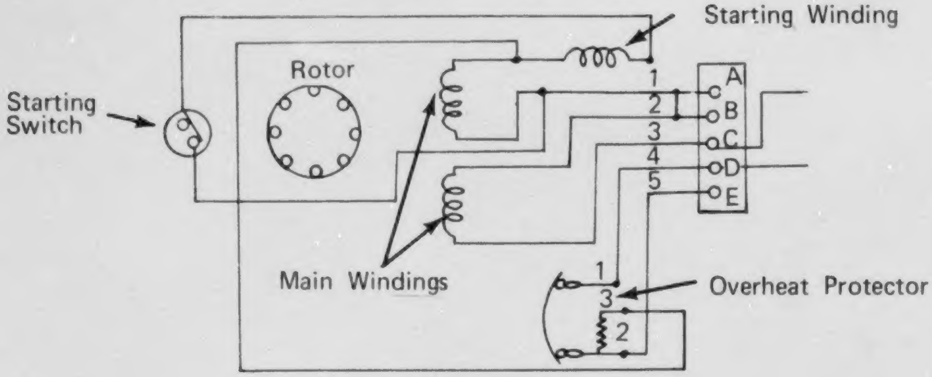
a. ______________________


T2
T1
Power Source
T3
T4

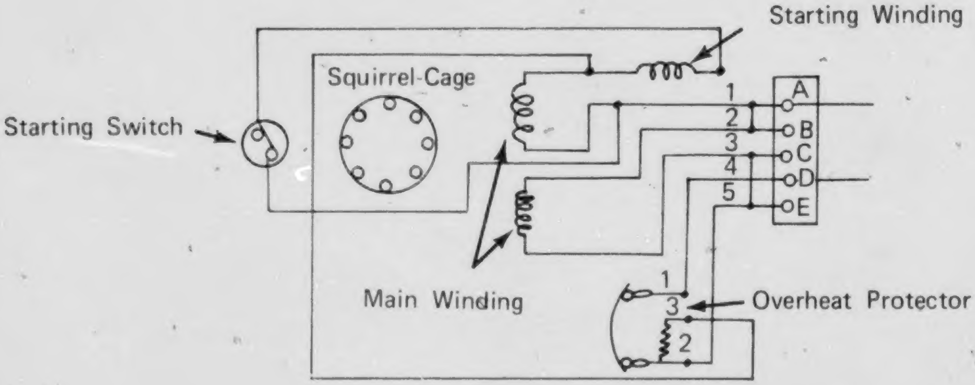
b. ______________________


T2
T1
Power
Source
T3
T4

11. Identify the motor power wirings.


Starting Winding
Rotor
Starting Switch
1
2
3
4
5
A
B
C
D
E
Main Windings
1
3
2
Overheat Protector

a. ____________________


Starting Winding
Squirrel-Cage
Starting Switch
1
2
3
4
5
A
B
C
D
E
Main Winding
1
3
2
Overheat Protector

b. ____________________

12. Demonstrate the ability to:

a. Wire a split-phase dual voltage motor to a 208/240 VAC supply.

b. Disassemble, inspect, clean, and reassemble a split-phase motor.

(NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

SPLIT-PHASE MOTORS
UNIT II

ANSWERS TO TEST

1. a. 4
   b. 3
   c. 1
   d. 2
2. 1/20 to 3/4
3. Any four of the following:
   a. Fans
   b. Oil burners
   c. Pumps
   d. Blowers
   e. Domestic refrigerator compressors
4. a. Start
   b. Run
5. a. Start winding
      1) High resistance
      2) Small wire
      3) More turns
      4) Wound on top of run winding in pole slots
   b. Run winding
      1) Low resistance
      2) Heavier wire
      3) Fewer turns
      4) Wound in bottom of pole slots

6. Discussion should include--Removes starting winding when motor reaches approximately 75 to 80% of its synchronous speed

7.
    a. Overload (inherent motor protection)
    b. Rotor
    c. Centrifugal starting mechanism or relay
    d. Starting winding
    e. Run winding

8.
    a. 2
    b. 1
    c. 2
    d. 1

9.
    a. 1
    b. 2
    c. 4
    d. 3

10.
    a. Counterclockwise
    b. Clockwise

11.
    a. 208/240 VAC
    b. 120 VAC

12. Performance skills evaluated to the satisfaction of the instructor

SHADED-POLE MOTORS
UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to define terms, list applications, and list disadvantages of shaded-pole motors. The student should also be able to discuss stator construction, methods of reversing rotation, methods of varying motor speed, and check a shaded-pole motor. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Define terms associated with shaded-pole motors.
2. List applications of shaded-pole motors.
3. Discuss the stator construction of the shaded-pole motor.
4. Match number of poles to the correct motor RPM.
5. List three disadvantages of shaded-pole motors.
6. List the two voltages for shaded-pole motors.
7. Discuss the methods of reversing rotation of shaded-pole motors.
8. Discuss the methods of varying the speed in shaded-pole motors.
9. State the most common remedy of shaded-pole motor failure.
10. Demonstrate the ability to check a shaded-pole motor.

SHADED-POLE MOTORS
UNIT III

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate and discuss the procedure outlined in the job sheet.

   G. Show several different styles of shaded-pole motors.

   H. Disassemble a shaded-pole motor and place on a display board.

   I. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Complete job sheet.

   D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM 1--Stator Construction

      2. TM 2--Electrical Reversal of Rotation

      3. TM 3--Methods of Varying Motor Speed

D. Job Sheet #1--Check a Shaded-Pole Motor

E. Test

F. Answers to test

II. References:

A. Schweitzer, Gerald. *Basics of Fractional Horsepower Motors and Repair.* Rochelle Park, New Jersey: Hayden Book Co., Inc., 1960.

B. Althouse, Andrew D.; Turnquist, Carl H.; and Bracciano, Alfred F. *Modern Refrigeration and Air Conditioning.* Homewood, Illinois: Goodheart-Willcox Co., 1975.

SHADED-POLE MOTORS
UNIT III

INFORMATION SHEET

I. Terms and definitions

   A. Reactor coil--Coil of many turns of fine magnet wire which is wired in series with the stator of a shaded-pole motor to provide a lower speed

   (NOTE: This coil is sometimes called a choke and looks similar to a transformer.)

   B. Shading coil--Closed loop of wire placed in a slot in the motor's stator pole and provides a phase shift to aid in motor starting and determines direction of rotation

II. Applications of shaded-pole motors

   A. Refrigerator evaporator fans

   B. Refrigerator condenser fans

   C. Window air-conditioner fans

   D. Furnace blowers

   E. Furnace combustion fans

   F. Timers

III. Stator construction (Transparency 1)

   A. Laminated poles

   B. Poles are slotted

   C. Stator winding is below shading slot

   D. Each shading coil is a closed loop

IV. Number of poles and motor RPM

   A. Two pole--3,000 RPM

   B. Four pole--1,500 RPM

   C. Six pole--1,050 to 1,100 RPM

   (NOTE: Motor RPM is determined by the number of poles.)

INFORMATION SHEET

V. Disadvantages of shaded-pole motors

- A. Low torque
- B. Speed variations

  (NOTE: The speed of a shaded-pole motor may vary over a wide range with a change in either load or the applied voltage.)
- C. Inefficient

VI. Voltages for shaded-pole motors

- A. 120 VAC single-phase
- B. 208/240 VAC single-phase

(NOTE: Shaded-pole motors are not available in either dual or three-phase voltages.)

VII. Methods of reversing rotation of shaded-pole motors

- A. Mechanical
  - 1. Rotor reversal
    - a. Disassemble motor
    - b. Reverse rotor assembly in stator
    - c. Reassemble motor
  - 2. Changing shading slot
    - a. Disassemble motor
    - b. Remove rotor assembly
    - c. Cut new shading slots in opposite side
    - d. Move shading coils to new slots
    - e. Reassemble motor

    (NOTE: These procedures are not recommended for field use but may be necessary in extreme situations.)

INFORMATION SHEET

B. Electrical

1. Two sets of field coils per shading coil (Transparency 2)

   a. Use a double pole double throw switch

   b. Position of switch determines direction of rotation

2. Two shaded-pole stators within one frame

   a. Four motor leads

   b. Connect the set of leads needed for the rotation desired

   (NOTE: These electrical characteristics have to be built into the motor at the time of manufacture.)

VIII. Methods of varying speed (Transparency 3)

A. Tapped stator winding

1. High speed--Least resistance portion of winding

2. Low speed--Complete winding high resistance

B. Reactor coil

1. Wired in series with stator winding

2. Low speed--Through reactor

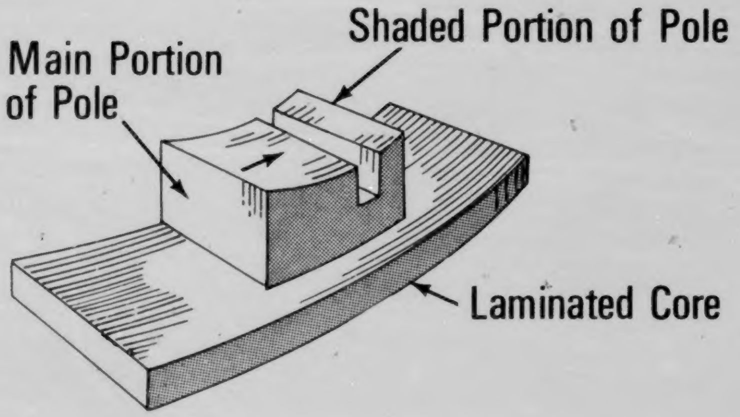
3. High speed--By-pass reactor

IX. Most common remedy of shaded-pole motor failure--Replacement

(NOTE: Shaded-pole motors are relatively inexpensive and they are time-consuming to disassemble and repair. Therefore, replacement is the generally accepted procedure instead of major repair.)

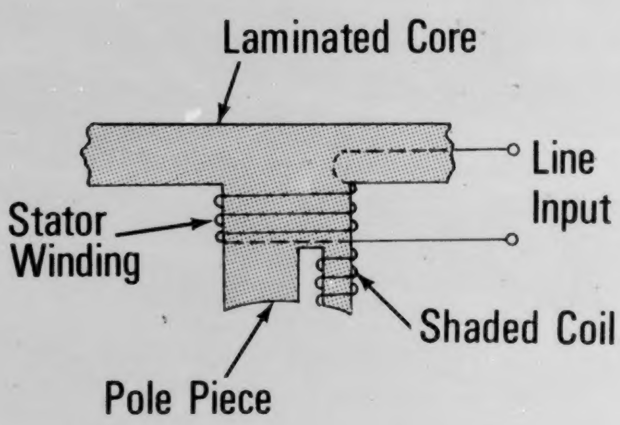
Stator Construction

Pole of a Shaded–Pole Motor


Shaded Portion of Pole
Main Portion of Pole
Laminated Core

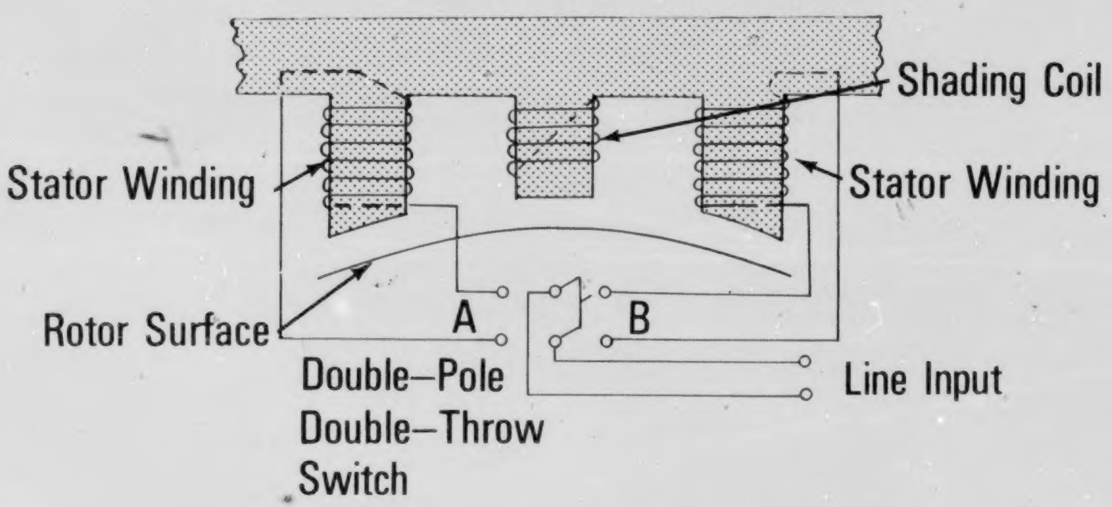
Note: Arrow on Main Portion of Pole Indicates Direction of Rotor Rotation

Placing Stator Windings on a Shaded–Pole Motor


Laminated Core
Line Input
Stator Winding
Shaded Coil
Pole Piece

Electrical Reversal of Rotation

One Pole of Laminated Core Cut into 3 Subpoles

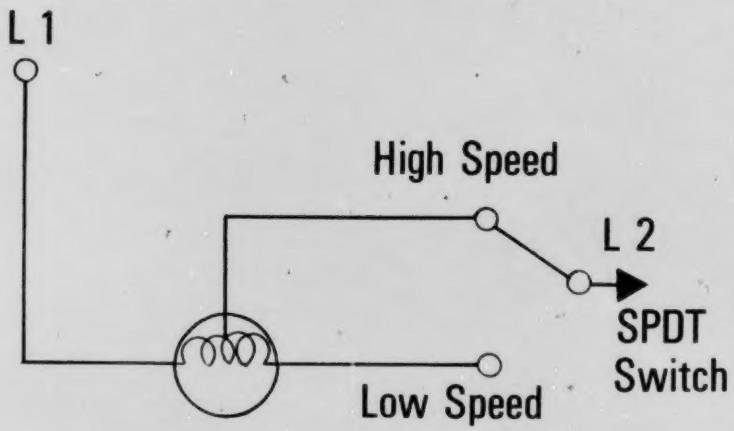

Shading Coil
Stator Winding
Stator Winding
Rotor Surface
A
B
Double–Pole
Double–Throw
Switch
Line Input

With Switch at A, Rotation is Clockwise

With Switch at B, Rotation is Counterclockwise

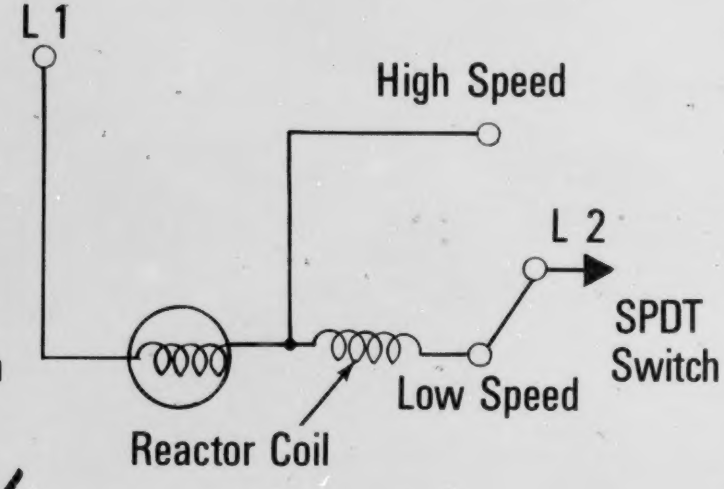
Methods of Varying Motor Speed

Tapped Winding

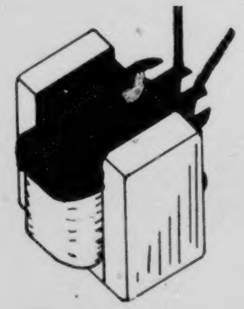

L 1
High Speed
L 2
SPDT
Switch
Low Speed

Shaded–Pole Motor

Reactor In Circuit


L 1
High Speed
L 2
SPDT
Switch
Low Speed
Reactor Coil

Shaded – Pole Motor



Reactor

SHADED-POLE MOTORS
UNIT III

JOB SHEET #1--CHECK A SHADED-POLE MOTOR

I. Tools and materials

- A. Shaded-pole motor
- B. Power cord with test clips
- C. Ammeter or wattmeter
- D. Bench vise
- E. Compressed air
- F. Motor cleaning fluid
- G. Shop towel
- H. Safety glasses
- I. Ohmmeter
- J. Polishing cloth

II. Procedure

- A. Place motor in bench vise
- B. Put on safety glasses
- C. Clean motor with compressed air
- D. Clean outside of motor with cleaning fluid

  (NOTE: Motors that are cleaned will run cooler and more efficiently.)
- E. Use ohmmeter to determine high and low speeds on stator tapped motors
- F. Take hold of motor shaft
- G. Check side play
- H. Check end play
- I. Have instructor check if side play or end play is excessive
- J. Connect test cord to motor leads

JOB SHEET #1

K. Clamp ammeter around one motor lead or connect wattmeter

L. Plug in power cord

M. Check amperage reading

N. Compare amperage reading to F.L.A. on motor

O. Have instructor check

P. Clean up and put away tools

SHADED-POLE MOTORS
UNIT III

NAME______________________________

TEST

1. Define the terms associated with shaded-pole motors.

   a. Reactor coil--

   b. Shading coil--

2. List five applications of shaded-pole motors.

   a.

   b.

   c.

   d.

   e.

3. Discuss the stator construction of the shaded-pole motor.

4. Match the number of poles on the right to the correct motor RPM.

______a. 1,500 RPM 1. Two pole

______b. 3,000 RPM 2. Six pole

______c. 1,050-1,100 RPM 3. Four pole

5. List three disadvantages of shaded-pole motors.

a.

b.

c.

6. List the two voltages for shaded-pole motors.

a.

b.

7. Discuss the methods of reversing rotation of shaded-pole motors.

a. Mechanical

b. Electrical

8. Discuss the methods of varying the speed in shaded-pole motors.

9. State the most common remedy of shaded-pole motor failure.

10. Demonstrate the ability to check a shaded-pole motor.

(NOTE: If this activity has not been accomplished prior to the test, ask your instructor when it should be completed.)

SHADED-POLE MOTORS
UNIT III

ANSWERS TO TEST

1. a. Reactor coil--Coil of many turns of fine magnet wire which is wired in series with the stator of a shaded-pole motor to provide a lower speed

   b. Shading coil--Closed loop of wire placed in a slot in the motor's stator pole and provides a phase shift to aid in motor starting and determines direction of rotation

2. Any five of the following:

   a. Refrigerator evaporator fans

   b. Refrigerator condenser fans

   c. Window air-conditioner fans

   d. Furnace blowers

   e. Furnace combustion fans

   f. Timers

3. Discussion should include:

   a. Laminated poles

   b. Poles are slotted

   c. Stator winding is below shading slot

   d. Each shading coil is a closed loop

4. a. 3

   b. 1

   c. 2

5. a. Low torque

   b. Speed variations

   c. Inefficient

6. a. 120 VAC single-phase

   b. 208/240 VAC single-phase

2

7. Discussion should include:
   a. Mechanical
      1) Rotor reversal
         a) Disassemble motor
         b) Reverse rotor assembly in stator
         c) Reassemble motor
      2) Changing shading slot
         a) Disassemble motor
         b) Remove rotor assembly
         c) Cut new shading slots in opposite side
         d) Move shading coils to new slots
         e) Reassemble motor
   b. Electrical
      1) Two sets of field coils per shading coil
         a) Use a double pole double throw switch
         b) Position of switch determines direction of rotation
      2) Two shaded-pole stators within one frame
         a) Four motor leads
         b) Connect the set of leads needed for the rotation desired
8. Discussion should include:
   a. Tapped stator winding
      1) High speed--Least resistance portion of winding
      2) Low speed--Complete winding high resistance
   b. Reactor coil
      1) Wired in series with stator winding
      2) Low speed--Through reactor
      3) High speed--By-pass reactor
9. Replacement
10. Performance skill evaluated to the satisfaction of the instructor

CAPACITOR MOTORS
UNIT IV

UNIT OBJECTIVE

After completion of this unit, the student should be able to define terms associated with capacitor motors, list two types of capacitor motors, discuss capacitor motors, identify the wiring diagrams of different capacitor motors, and start a seized hermetic compressor. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Define terms associated with capacitor motors.
2. List two types of capacitor motors.
3. Discuss the characteristics of capacitor motors.
4. Discuss C.S.I.R. (Capacitor Start-Induction Run) motors.
5. Discuss C.S.R. (Capacitor Start-Capacitor Run) motors.
6. Discuss P.S.C. (Permanent Split Capacitor) motors.
7. Identify the wiring diagrams of C.S.I.R., C.S.R., and P.S.C. motors.
8. Demonstrate the ability to start a seized hermetic compressor motor.

CAPACITOR MOTORS
UNIT IV

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate and discuss the procedures outlined in the job sheet.

   G. Show students actual capacitor motors.

   H. Disassemble a capacitor motor and place on a display board.

   I. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Complete job sheet.

   D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM 1--C.S.I.R. Motor Wiring

      2. TM 2--C.S.R. Motor Wiring

      3. TM 3--P.S.C. Motor Wiring

D. Job sheets

  1. Job Sheet #1--Start a Seized Hermetic Compressor Motor

E. Test

F. Answers to test

II. References:

A. Schweitzer, Gerald. *Basics of Fractional Horsepower Motors and Repair.* Rochelle Park, New Jersey: Hayden Book Co., Inc., 1960.

B. Grim, John H. *Refrigeration System Components.* Sidney, Ohio: Copeland Refrigeration Corp., 1967.

C. Althouse, Andrew D.; Turnquist, Carl H.; and Bracciano, Alfred F. *Modern Refrigeration and Air Conditioning.* Homewood, Illinois: Goodheart-Willcox Co., 1975.

CAPACITOR MOTORS
UNIT IV

INFORMATION SHEET

I. Terms and definitions

  A. Dual-voltage motors--Motors which are designed to operate on more than one voltage

  B. Capacitor motors--Motors which use a start capacitor and/or a run capacitor in the electrical circuit

  C. Hermetic motor--Motor which is sealed in the hermetic dome with the compressor

II. Types of capacitor motors

  A. Open drive

  B. Hermetic

III. Characteristics of capacitor motors

  A. Essentially the same design as a split-phase motor

  (CAUTION: Do not attempt to increase the torque of a split-phase motor by inserting a start capacitor in series with the start winding. The windings of split-phase motors and capacitor motors are designed differently and the insertion of a start capacitor in a split-phase motor would cause permanent damage.)

  B. Start capacitor is in series with start winding

  C. Higher starting torque

  D. More efficient, less amperage draw

  E. Run capacitor is parallel to both windings

IV. C.S.I.R. (Capacitor Start-Induction Run) motors (Transparency 1)

  A. Designed for heavier loads than split-phase motors

  B. A switch must be provided to remove start capacitor from circuit after starting

  C. Available in single or dual voltage

V. C.S.R. (Capacitor Start-Capacitor Run) motors (Transparency 2)

  A. High starting torque

  B. High efficiency, lower amperage draw

INFORMATION SHEET

- C. High power factor
- D. Increased capacitance at instant of start
- E. Start winding stays in phase with run winding

  (NOTE: This enables the start winding to help the load requirements of the run winding.)

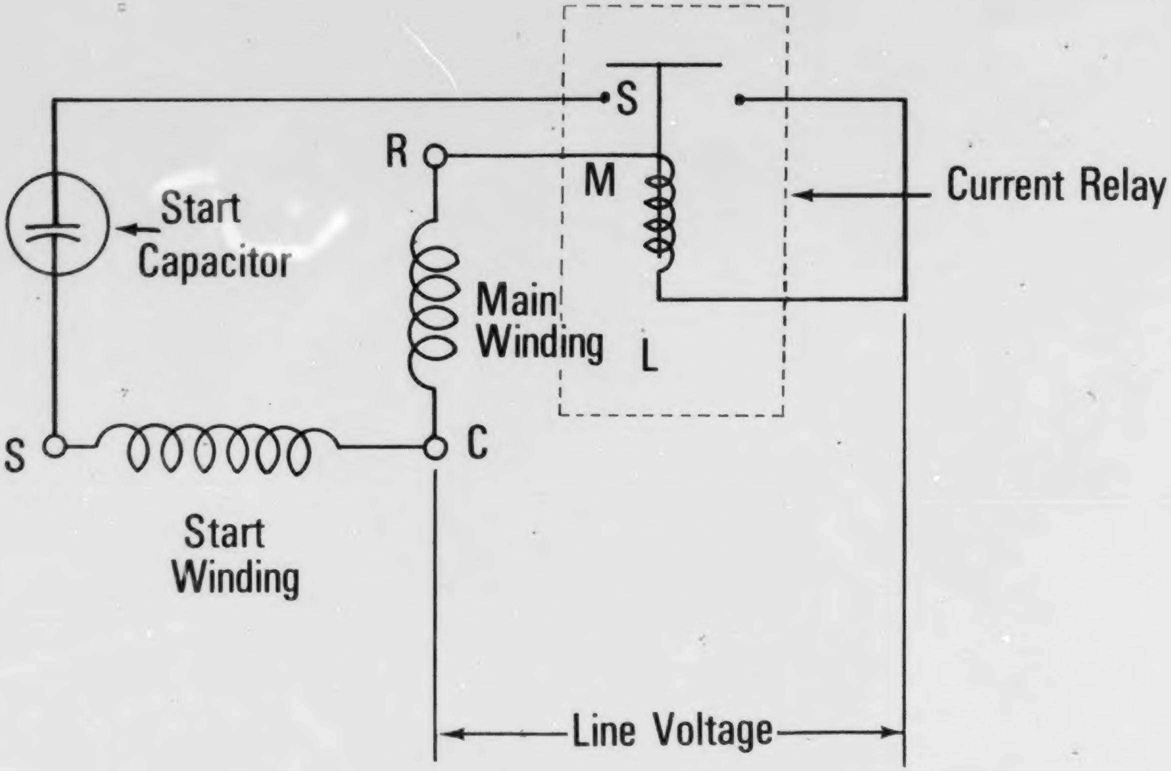
VI. P.S.C. (Permanent Split Capacitor) motors (Transparency 3)

- A. No centrifugal switch in open drive motors
- B. Low starting torque
- C. No motor starting relay
- D. Direction of rotation may be reversed
- E. Potential relay and start capacitor may be added for increased starting torque

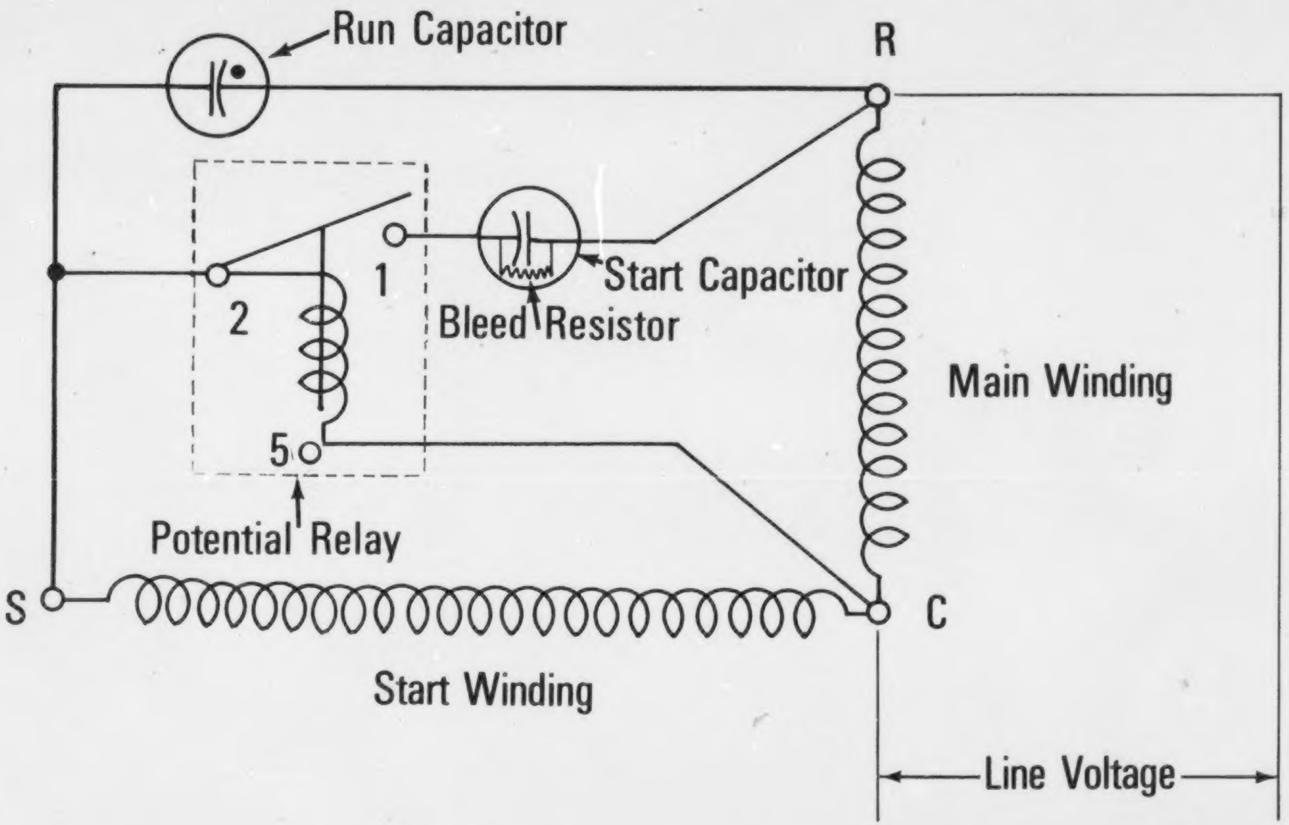
  (NOTE: The addition of a potential relay and a start capacitor to a P.S.C. motor is referred to as a hard start kit.)

VII. Wiring diagrams of C.S.I.R., C.S.R., and P.S.C. motors (Transparencies 1, 2, and 3)

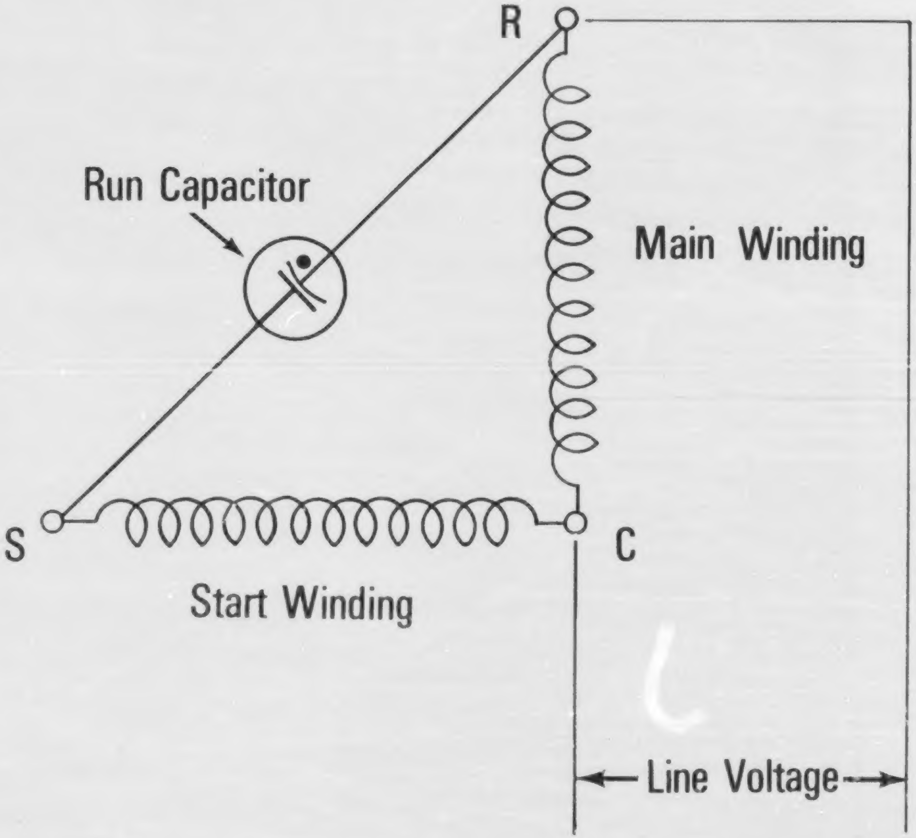
C.S.I.R. Motor Wiring


S
R
M
Current Relay
Start
Capacitor
Main
Winding
L
S
C
Start
Winding
Line Voltage

C.S.R. Motor Wiring


Run Capacitor
R
Start Capacitor
Bleed Resistor
1
2
5
Potential Relay
Main Winding
S
C
Start Winding
Line Voltage

P.S.C. Motor Wiring


R
Run Capacitor
Main Winding
S
C
Start Winding
Line Voltage

CAPACITOR MOTORS
UNIT IV

JOB SHEET #1--START A SEIZED HERMETIC COMPRESSOR MOTOR

(NOTE: The success of starting a seized compressor is very limited and if it does start it is very likely that it will seize again.)

I. Tools and materials

   A. 120 VAC stuck hermetic compressor

   B. Hermetic analyzer

   C. Run capacitor

   D. Rubber mallet

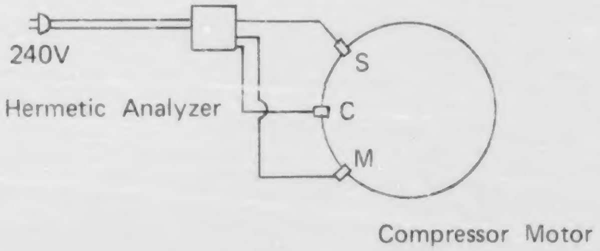
   E. Ohmmeter

II. Procedure for using higher voltage momentarily

   A. Remove starting components from compressor

   B. Connect hermetic analyzer to compressor (Figure 1)

FIGURE 1



   C. Connect analyzer power cord to 240 VAC supply

   D. Momentarily attempt to start the 120 VAC compressor with 240 VAC

   (CAUTION: Do not leave the 240 VAC applied to the compressor for more than a few seconds.)

   E. Bump the compressor with the rubber mallet a couple of times

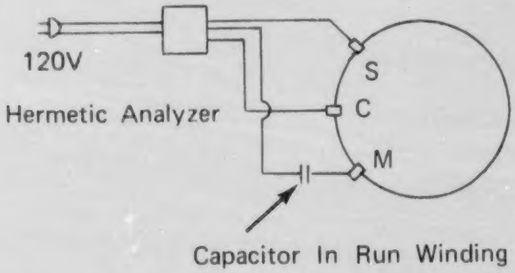
III. Procedure for reversing rotation

   A. Connect analyzer power cord to 120 VAC power supply

JOB SHEET #1

B. Place a run capacitor in series with the run winding (Figure 2)

FIGURE 2


120V
Hermetic Analyzer
S
C
M
Capacitor In Run Winding

(NOTE: This will reverse the direction of rotation of the compressor motor.)

C. Have instructor check

D. Disconnect hermetic analyzer from power supply

E. Disconnect hermetic analyzer from compressor

F. Replace starting components on compressor

G. Clean up and put away tools

CAPACITOR MOTORS
UNIT IV

TEST

NAME________________________

1. Define the terms associated with capacitor motors.

   a. Capacitor motors--

   b. Dual-voltage motors--

   c. Hermetic motors--

2. List two types of capacitor motors.

   a.

   b.

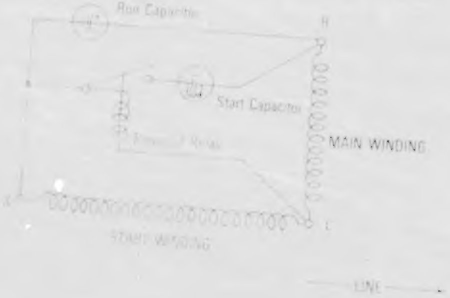
3. Discuss the characteristics of capacitor motors.

4. Discuss C.S.I.R. (Capacitor Start-Induction Run) motors.

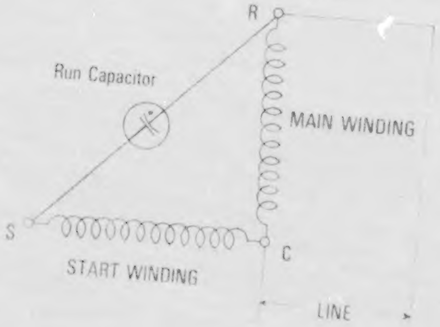
5. Discuss C.S.R. (Capacitor Start-Capacitor Run) motors.

6. Discuss P.S.C. (Permanent Split Capacitor) motors.

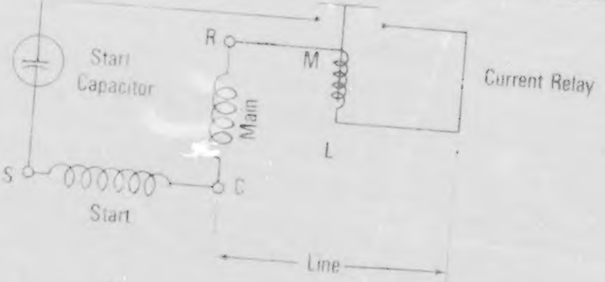
7. Identify the wiring diagrams of C.S.I.R., C.S.R., and P.S.C. motors.


Run Capacitor
R
Start Capacitor
Potential Relay
MAIN WINDING
S
C
START WINDING
LINE

a. ____________________________


R
Run Capacitor
MAIN WINDING
S
C
START WINDING
LINE

b. ____________________________


Start Capacitor
R
M
Current Relay
Main
L
S
C
Start
Line

c. ____________________________

8. Demonstrate the ability to start a seized hermetic compressor motor.

(NOTE: If this activity has not been accomplished prior to the test, ask your instructor when it should be completed.)

CAPACITOR MOTORS
UNIT IV

ANSWERS TO TEST

1. a. Capacitor motors--Motors which use a start capacitor and/or a run capacitor in the electrical circuit

   b. Dual-voltage motors--Motors which are designed to operate on more than one voltage

   c. Hermetic motor--Motor which is sealed in the hermetic dome with the compressor

2. a. Open drive

   b. Hermetic

3. Discussion should include:

   a. Essentially the same design as a split-phase motor

   b. Start capacitor is in series with start winding

   c. Higher starting torque

   d. More efficient, less amperage draw

   e. Run capacitor is parallel to both windings

4. Discussion should include:

   a. Designed for heavier loads than split-phase motors

   b. A switch must be provided to remove start capacitor from circuit after starting

   c. Available in single or dual voltage

5. Discussion should include:

   a. High starting torque

   b. High efficiency, lower amperage draw

   c. High power factor

   d. Increased capacitance at instant of start

   e. Start winding stays in phase with run winding

6. Discussion should include:
    a. No centrifugal switch in open drive motors
    b. Low starting torque
    c. No motor starting relay
    d. Direction of rotation may be reversed
    e. Potential relay and start capacitor may be added for increased starting torque
7. a. C.S.R.
    b. P.S.C.
    c. C.S.I.R.
8. Performance skills evaluated to the satisfaction of the instructor

THREE-PHASE MOTORS
UNIT V

UNIT OBJECTIVE

After completion of this unit, the student should be able to match terms, list types of three-phase motors, discuss the characteristics of various types of three-phase motors, and describe the procedure of reversing the rotation of a three-phase motor. This knowledge will be evidenced by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with three-phase motors to the correct definitions.
2. List the three major types of three-phase motors.
3. Discuss the electrical characteristics of three-phase motors and their components.
4. Distinguish between a symbolic drawing of a delta wound motor and a symbolic drawing of a wye "Y" wound motor.
5. Discuss the synchronous motor.
6. Discuss the squirrel-cage motor.
7. Discuss the wound-rotor motor.
8. Describe the procedure of reversing the rotation of a three-phase motor.

THREE-PHASE MOTORS
UNIT V

SUGGESTED ACTIVITIES

I. Instructor:

  A. Provide student with objective sheet.

  B. Provide student with information sheet.

  C. Make transparencies.

  D. Discuss unit and specific objectives.

  E. Discuss information sheet.

  F. Disassemble a three-phase motor and place it on a display board.

  G. Have student check the wiring connections on six and nine lead motors.

  H. Give test.

II. Student:

  A. Read objective sheet.

  B. Study information sheet.

  C. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

  A. Objective sheet

  B. Information sheet

  C. Transparency masters

    1. TM 1--Wye Motor Lead Connections

    2. TM 2--Delta Wound Motor

    3. TM 3--Wye "Y" Wound Motor (Single Speed)

    4. TM 4--Synchronous Motor

        5. TM 5--Squirrel-Cage Rotor

        6. TM 6--Wound-Rotor Motor

    D. Test

    E. Answers to test

II. References:

    A. Schweitzer, Gerald. *Basics of Fractional Horsepower Motors and Repair.* Rochelle Park, New Jersey: Hayden Book Co., 1960.

    B. Paraday, W. Harold; Turner, J. Howard; and Colvin, Thomas S. *How Electric Motors Start and Run.* Athens, Georgia: American Association for Vocational Instructional Materials, July 1973.

THREE-PHASE MOTORS
UNIT V

INFORMATION SHEET

I. Terms and definitions

   A. Synchronous--Constant speed to which an alternating current motor adjusts itself, depending on the frequency of the power supply and the number of poles in the motor

   B. Squirrel-cage rotor--Rotor consisting of two discs connected along their circumference with copper bars which creates a shunted circuit

   (NOTE: The squirrel-cage motor derives its name by using the squirrel-cage rotor.)

   C. Wound-rotor induction motor--Similar to the squirrel-cage rotor with the exception that the windings are insulated rather than shunted and the current is picked up through carbon brushes

   D. Adjustable autotransformer--Transformer in which parts of one winding are common to both the primary and the secondary circuits, and the output voltage is adjustable from zero to line voltage

   (NOTE: A trade name for this is a Variac.)

   E. Brush--Piece of carbon or graphite which is an internal part of a motor and rides on the commutator or slip rings to provide an electrical connection to the rotor

   F. Variable resistor--Wire wound resistor in which the resistance may be selected through a given range by turning of the control shaft

II. Major types of three-phase motors

   A. Synchronous

   B. Squirrel-cage rotor

   C. Wound-rotor

III. Electrical characteristics of three-phase motors and their components

   A. Three-phase supply voltage

   B. May be dual or single voltage

      1. Single voltage has three motor leads

INFORMATION SHEET

2. Dual voltage has six or nine motor leads

   Example: A 208-220/440 VAC 3 phase motor will operate on either 208/220 VAC 3ph. power or 440 VAC 3 phase power. Motor lead connections are different for each. (Transparency 1)

C. Rotor

D. Stator

1. Three single-phase windings
2. Each winding is 120 electrical degrees out of phase with the adjacent winding

IV. Delta wound motor and wye "Y" wound motor (Transparencies 2 and 3)

V. Synchronous motor (Transparency 4)

A. Standard stator

B. A direct current source of excitation for rotor

1. Mounted on rotor shaft
2. Provides the starting torque

C. Small, low torque synchronous motors are nonexcited

D. High power factor

VI. Squirrel-cage motor (Transparency 5)

(NOTE: The squirrel-cage motor derives its name by use of the squirrel-cage rotor.)

A. Induction start and run

B. Speed is determined by two conditions

1. Frequency
2. Number of poles

C. Low to medium starting torque

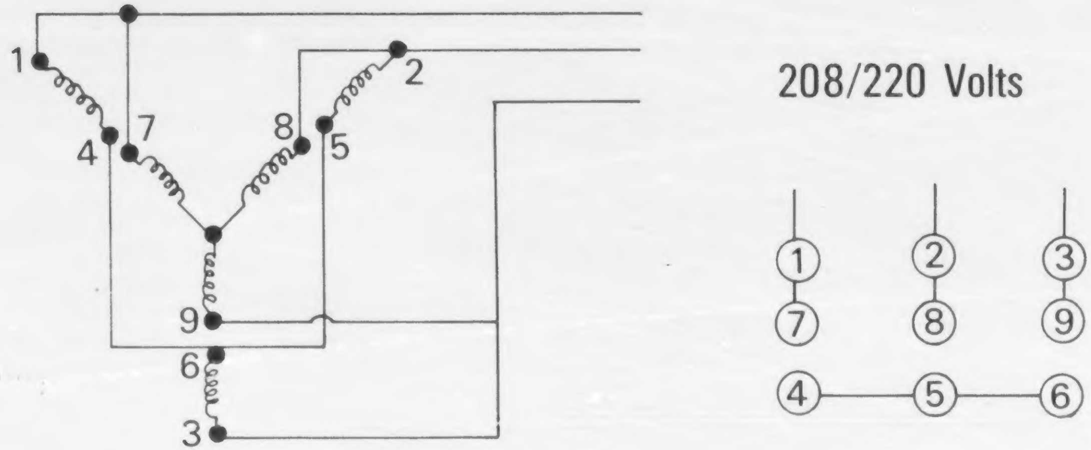
INFORMATION SHEET

VII. Wound-rotor motor (Transparency 6)

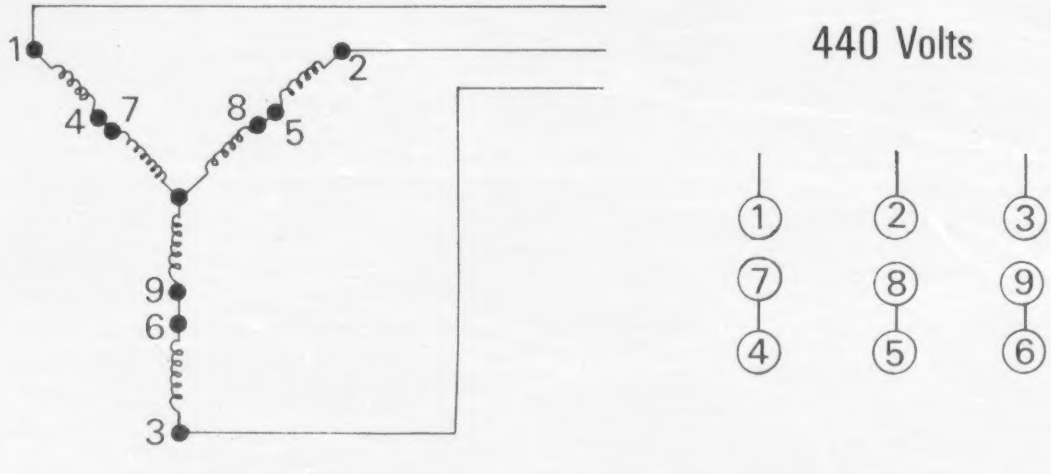
- A. Slip ring brushes
- B. Motor control
  - 1. Variable resistor
  - 2. Autotransformer
- C. Variable characteristics
  - 1. Starting torque
  - 2. Current
  - 3. Operating speed
  - 4. Acceleration
- D. Used mostly on heavy equipment which requires:
  - 1. High starting torque
  - 2. Smooth acceleration
  - 3. Variable speeds

VIII. Procedure of reversing the rotation of a three-phase motor--The rotation of any three-phase may be reversed by switching any two of the line voltage leads

Wye Motor Lead Connections

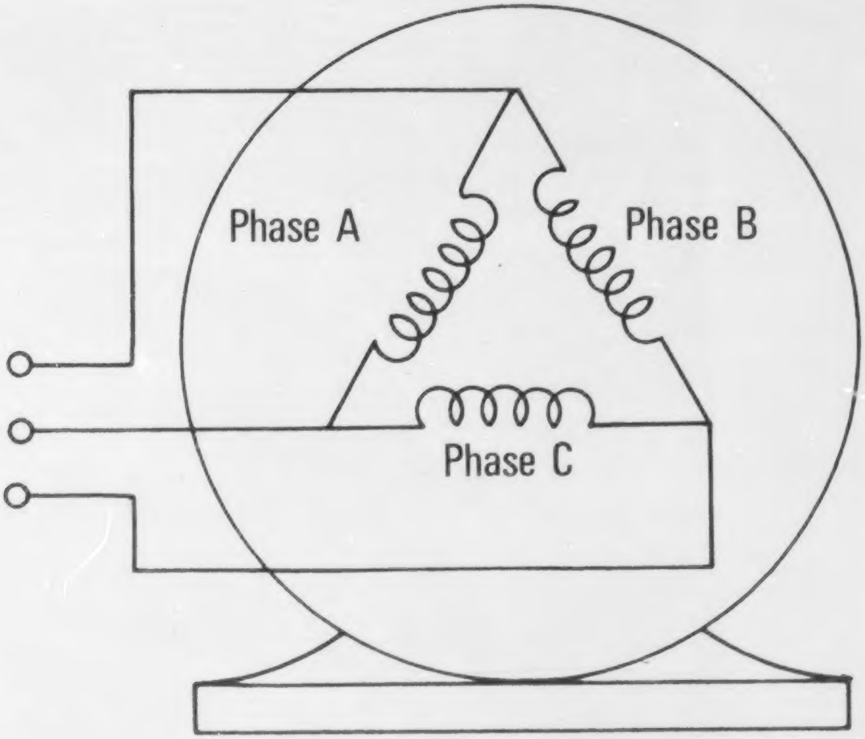

1
2
4
7
8
5
9
6
3
1
2
3
7
8
9
4
5
6

208/220 Volts


1
2
4
7
8
5
9
6
3
1
2
3
7
8
9
4
5
6

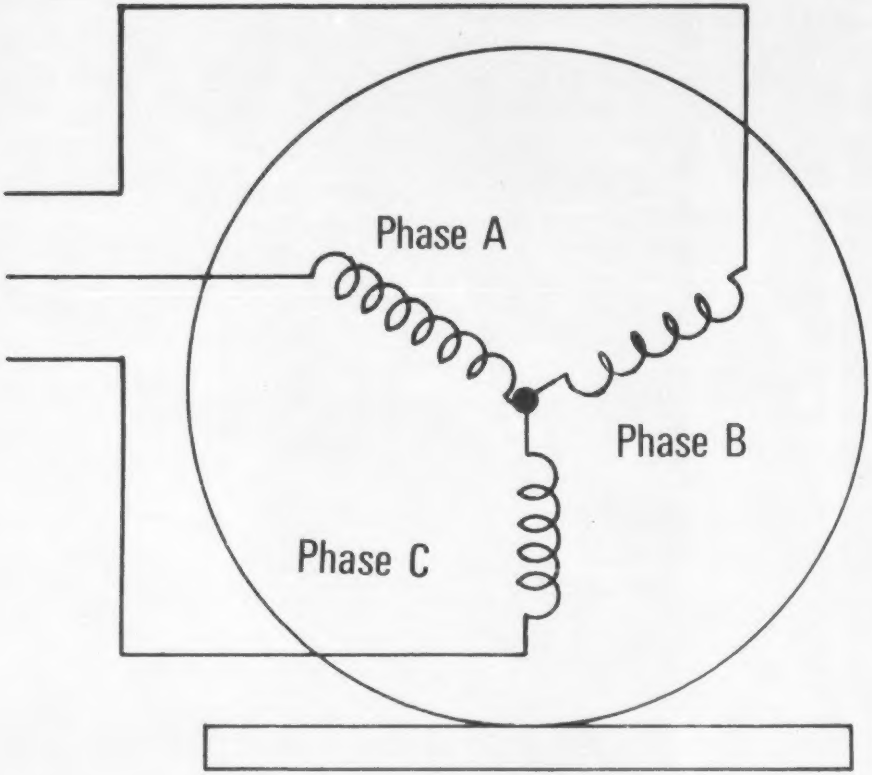
440 Volts

Delta Wound Motor


Phase A
Phase B
Phase C

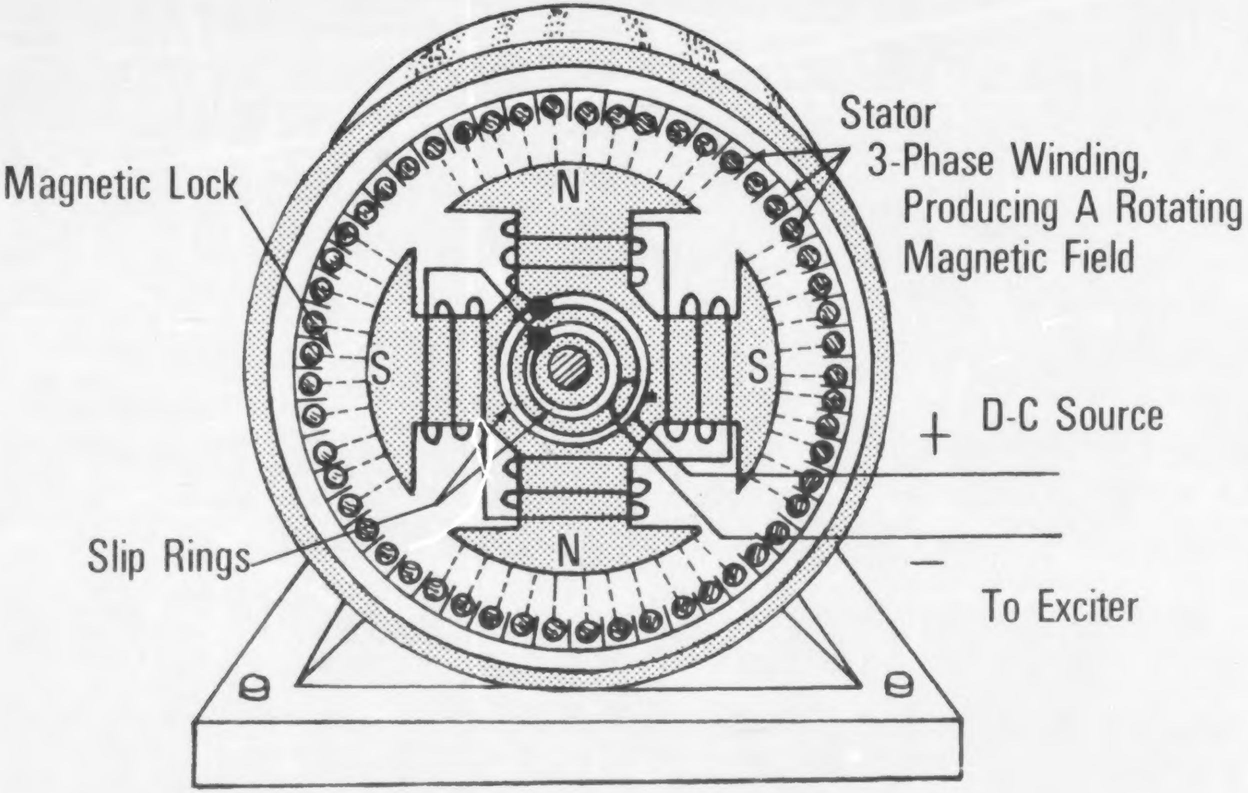
WYE "Y" Wound Motor

(Single Speed)

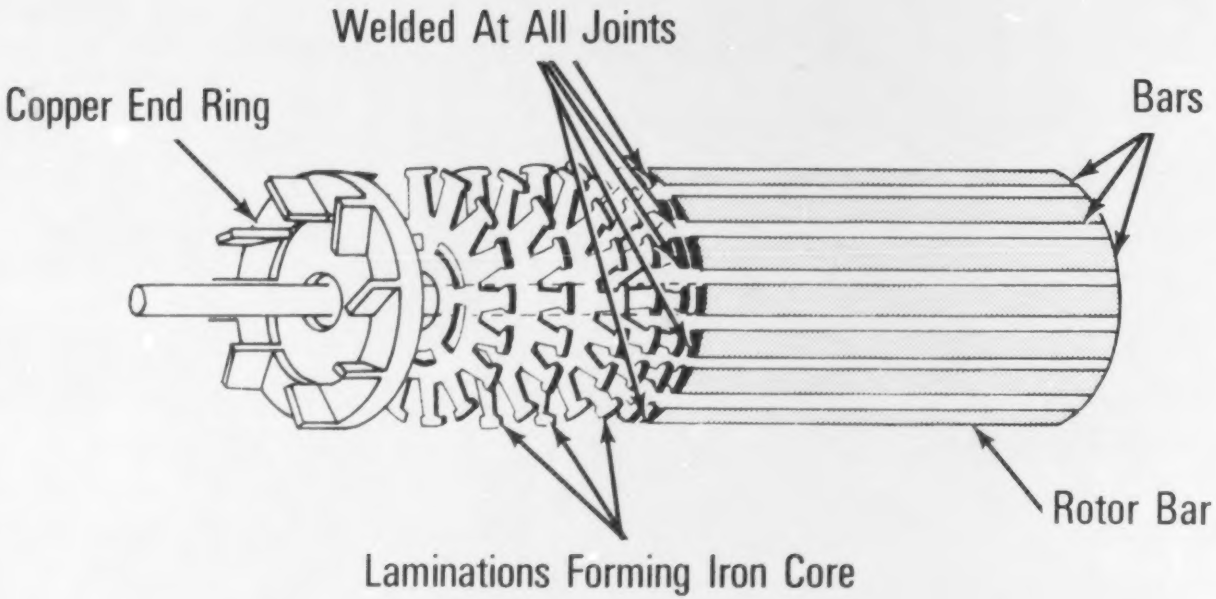

Phase A
Phase B
Phase C

TM 3

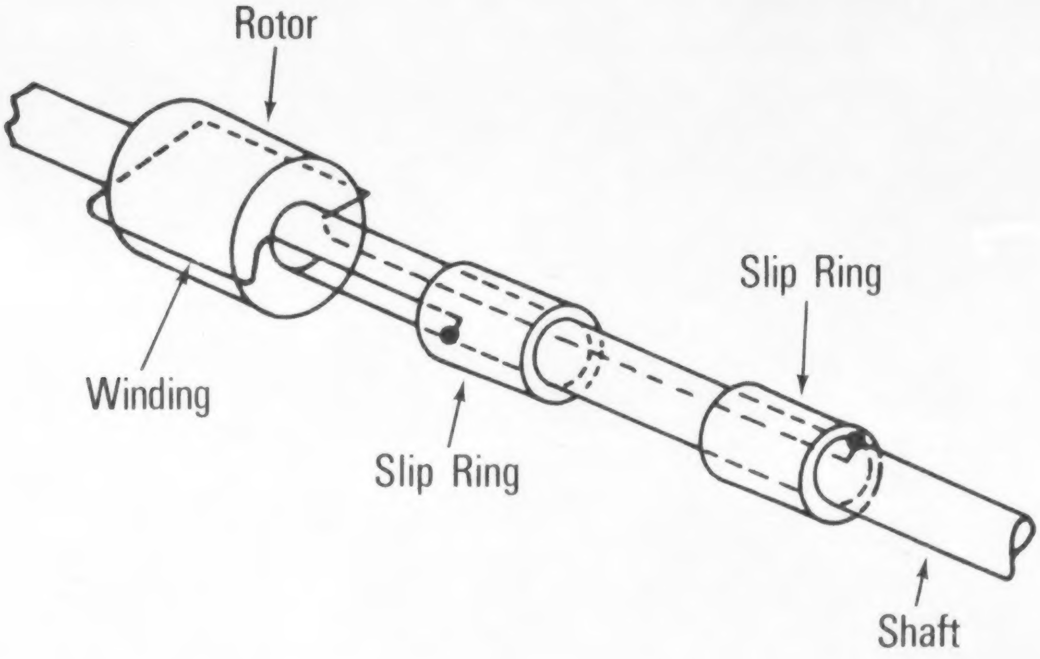
Synchronous Motor


Stator
3-Phase Winding,
Producing A Rotating
Magnetic Field
Magnetic Lock
N
S
S
N
+
D-C Source
−
To Exciter
Slip Rings

Squirrel-Cage Rotor


Welded At All Joints
Copper End Ring
Bars
Rotor Bar
Laminations Forming Iron Core

Wound-Rotor Motor


Rotor
Winding
Slip Ring
Slip Ring
Shaft

THREE-PHASE MOTORS
UNIT V

NAME ____________________

TEST

1. Match the terms on the right to the correct definitions.

_____a. Piece of carbon or graphite which is an internal part of a motor and rides on the commutator or slip rings to provide an electrical connection to the rotor

_____b. Rotor consisting of two discs connected along their circumference with copper bars which creates a shunted circuit

_____c. Constant speed to which an alternating current motor adjusts itself, depending on the frequency of the power supply and the number of poles in the motor

_____d. Transformer in which parts of one winding are common to both the primary and the secondary circuits, and the output voltage is adjustable from zero to line voltage

_____e. Similar to the squirrel-cage rotor with the exception that the windings are insulated rather than shunted and the current is picked up through carbon brushes

_____f. Wire wound resistor in which the resistance may be selected through a given range by turning of the control shaft

1. Brush
2. Squirrel-cage rotor
3. Synchronous
4. Variable resistor
5. Adjustable autotransformer
6. Wound-rotor induction motor

2. List the three major types of three-phase motors.

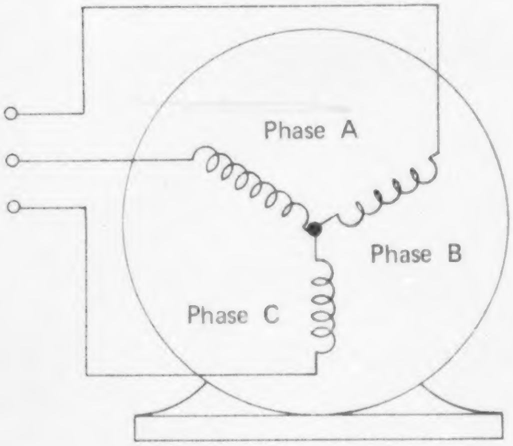
a.

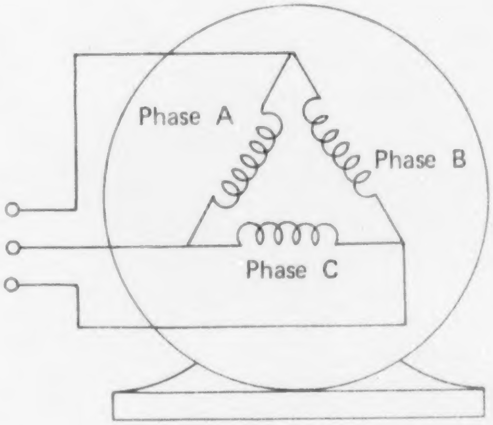
b.

c.

3. Discuss the electrical characteristics of three-phase motors and their components.

4. Distinguish between a symbolic drawing of a delta wound motor and a symbolic drawing of a wye "Y" wound motor by placing an "X" under the drawing of a delta wound motor.


Phase A
Phase B
Phase C


Phase A
Phase B
Phase C

a. ____________

b. ____________

5. Discuss the synchronous motor.

6. Discuss the squirrel-cage motor.

7. Discuss the wound-rotor motor.

8. Describe the procedure of reversing the rotation of a three-phase motor.

THREE-PHASE MOTOR
UNIT V

ANSWERS TO TEST

1. a. 1
   b. 2
   c. 3
   d. 5
   e. 6
   f. 4

2. a. Synchronous
   b. Squirrel-cage rotor
   c. Wound-rotor

3. Discussion should include:
   a. Three-phase supply voltage
   b. May be dual or single voltage
      1) Single voltage has three motor leads
      2) Dual voltage has six or nine motor leads
   c. Rotor
   d. Stator
      1) Three single-phase windings
      2) Each winding is 120 electrical degrees out of phase with the adjacent winding

4. b

5. Discussion should include:
   a. Standard stator
   b. A direct current source of excitation for rotor
      1) Mounted on rotor shaft
      2) Provides the starting torque
   c. Small, low torque synchronous motors are nonexcited
   d. High power factor

6. Discussion should include:
    a. Induction start and run
    b. Speed is determined by two conditions
        1) Frequency
        2) Number of poles
    c. Low to medium starting torque
7. Discussion should include:
    a. Slip ring brushes
    b. Motor control
        1) Variable resistor
        2) Autotransformer
    c. Variable characteristics
        1) Starting torque
        2) Current
        3) Operating speed
        4) Acceleration
    d. Used mostly on heavy equipment which requires:
        1) High starting torque
        2) Smooth acceleration
        3) Variable speeds
8. Description should include: The rotation of any three-phase may be reversed by switching any two of the line voltage leads

WIRING DIAGRAMS
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to match terms to their definitions, match symbols to component names, and distinguish between pictorial and schematic wiring diagrams. The student should also be able to draw pictorial and schematic wiring diagrams. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with wiring diagrams to the correct definitions.
2. Identify wiring diagrams.
3. List seven characteristics of a pictorial wiring diagram.
4. List five characteristics of a schematic wiring diagram.
5. List the four major steps in building a ladder schematic.
6. Discuss the schematic legend.
7. Match schematic symbols to component names.
8. Demonstrate the ability to:
    a. Draw a basic schematic wiring diagram.
    b. Draw current relay wiring diagrams.
    c. Draw potential relay wiring diagrams of a self-contained unit.
    d. Draw hot-wire relay wiring diagrams.
    e. Draw gas furnace wiring diagrams.
    f. Draw outdoor condensing unit wiring diagrams.
    g. Draw gas furnace wiring diagrams with two limit switches.
    h. Draw electric furnace wiring diagrams.

i. Draw indoor air handler and outdoor condensing unit wiring diagram.

j. Draw a domestic refrigerator wiring diagram.

k. Draw a ladder schematic by looking at a domestic refrigerator.

l. Draw a ladder schematic by looking at a window air conditioner.

m. Draw a ladder schematic by looking at a system with low voltage control circuit.

WIRING DIAGRAMS
UNIT I

SUGGESTED ACTIVITIES

I. Instructor:

- A. Provide student with objective sheet.
- B. Provide student with information, assignment, and job sheets.
- C. Make transparencies.
- D. Discuss unit and specific objectives.
- E. Discuss information and assignment sheets.
- F. Demonstrate and discuss the procedures outlined in the job sheets.
- G. Obtain wiring diagrams from different equipment manufacturers to show students.
- H. Have students make wiring diagrams for all of the equipment in the shop.
- I. Make games for teaching the principles of wiring diagrams such as: bingo, crossword puzzles, scrambled words, concentration, and flash cards.
- J. Make additional assignment and job sheets.
- K. Give test.

II. Student:

- A. Read objective sheet.
- B. Study information sheet.
- C. Complete assignment and job sheets.
- D. Practice making and reading wiring diagrams.
- E. Recheck all wiring on paper before doing any actual wiring.
- F. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

  A. Objective sheet

  B. Information sheet

  C. Transparency masters

    1. TM 1--Pictorial Wiring Diagram

    2. TM 2--Ladder Schematic Wiring Diagram

    3. TM 3--Symbols

    4. TM 4--Symbols (Continued)

  D. Assignment sheets

    1. Assignment Sheet #1--Draw a Basic Schematic Wiring Diagram

    2. Assignment Sheet #2--Draw Current Relay Wiring Diagrams

    3. Assignment Sheet #3--Draw Potential Relay Wiring Diagrams of a Self-Contained Unit

    4. Assignment Sheet #4--Draw Hot-Wire Relay Wiring Diagrams

    5. Assignment Sheet #5--Draw Gas Furnace Wiring Diagrams

    6. Assignment Sheet #6--Draw Outdoor Condensing Unit Wiring Diagrams

    7. Assignment Sheet #7--Draw Gas Furnace Wiring Diagrams with Two Limit Switches

    8. Assignment Sheet #8--Draw Electric Furnace Wiring Diagrams

    9. Assignment Sheet #9--Draw Indoor Air Handler and Outdoor Condensing Unit Wiring Diagram

    10. Assignment Sheet #10--Draw a Domestic Refrigerator Wiring Diagram

  E. Answers to assignment sheets

  F. Job sheets

    1. Job Sheet #1--Draw a Ladder Schematic by Looking at a Domestic Refrigerator

    2. Job Sheet #2--Draw a Ladder Schematic by Looking at a Window Air Conditioner

    3. Job Sheet #3--Draw a Ladder Schematic by Looking at a System with Low Voltage Control Circuit

G. Test

H. Answers to test

II. References:

A. Russell, Allen S. *Schematic Wiring Made Easy.* Marshalltown, Iowa: Allen Russell Associates, 1973.

B. Langley, B. C. *Electric Controls for Refrigeration and Air Conditioning.* Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1974.

C. Russell, Allen S. *Getting Started in Heating and Air Conditioning Service.* Birmingham, Michigan: Business News Publishing Co., 1973.

WIRING DIAGRAMS
UNIT I

INFORMATION SHEET

I. Terms and definitions

   A. Wiring diagram--Drawing of electrical circuits

   B. Pictorial--Wiring diagram which shows either pictures or representative drawings of each component; components are positioned as they would appear in the equipment

   C. Ladder schematic--Line drawing which uses symbols for circuit components

   (NOTE: The term ladder comes from the fact that each leg of the power supply is the side rails of the ladder and the parallel circuits across the line form the rungs of the ladder.)

   D. Legend--Descriptive list of the components in a wiring diagram

   E. Symbol--Drawing which represents a particular component in a wiring diagram

II. Wiring diagrams

   A. Pictorial (Transparency 1)

   B. Ladder schematic (Transparency 2)

III. Characteristics of pictorial wiring diagrams

   A. System components

      1. Representative drawings

      2. Detailed reproductions

   B. Shows components in their approximate location

   C. Provides a good guide for field wiring

   D. Circuits are difficult to trace

   E. Line voltage and low voltage circuits are shown together

IV. Characteristics of ladder schematic wiring diagrams

   A. System components are shown by symbols

   B. Schematic wiring diagrams build a ladder

   C. Ladder rungs are individual circuits

INFORMATION SHEET

D. Line voltage and low voltage are separated

E. Circuit troubleshooting is easy

V. Building a ladder schematic

A. Establish power source (Figure 1)

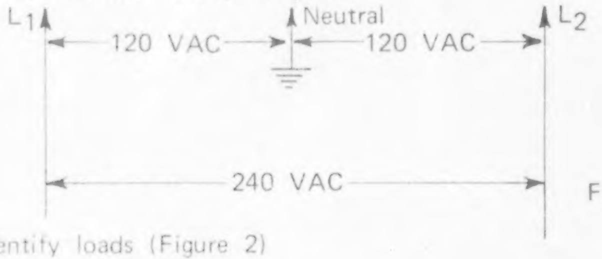
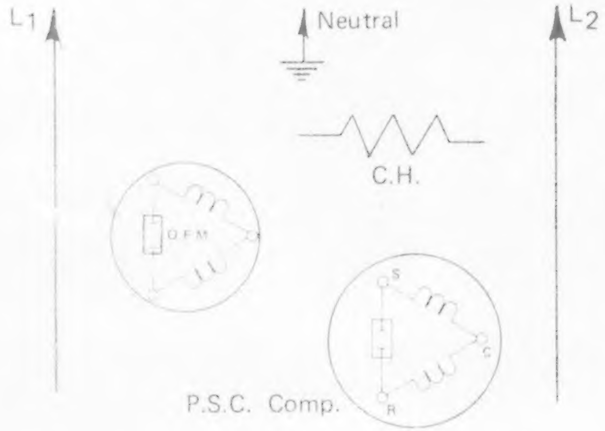

L_1
Neutral
L_2
120 VAC
120 VAC
240 VAC

FIGURE 1

B. Identify loads (Figure 2)

(NOTE: Each load will be a separate parallel circuit.)

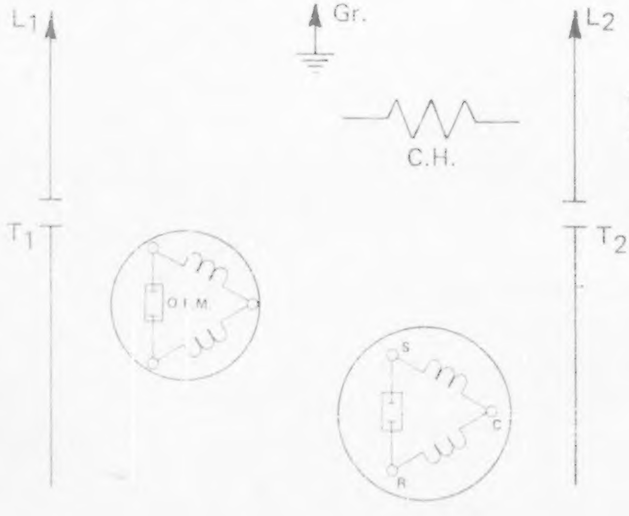

L_1
Neutral
L_2
C.H.
O.F.M.
P.S.C. Comp.
S
C
R

Loads

C.H.--Crankcase Heater
O.F.M.--Outdoor Fan Motor
P.S.C. Comp.--Permanent Split Capacitor Compressor

FIGURE 2

C. Identify control switches for each circuit (Figure 3)


L_1
Gr.
L_2
C.H.
T_1
T_2
O.F.M.
S
C
R

Switches

T_1--Set of Contactor Contacts
T_2--Set of Contactor Contacts

FIGURE 3

INFORMATION SHEET

D. Connect all circuits across the line (Figure 4)

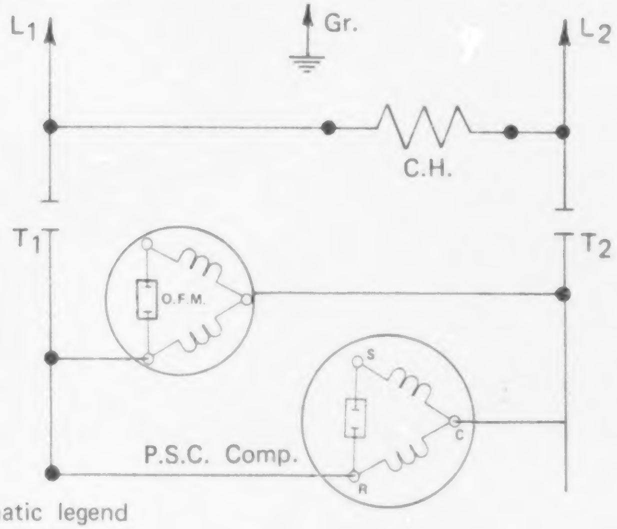

L1
Gr.
L2
C.H.
T1
T2
O.F.M.
S
C
R
P.S.C. Comp.

FIGURE 4

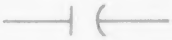
VI. Schematic legend

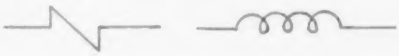
A. Identifies schematic components

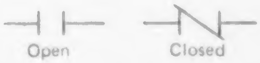
B. Distinguishes differences in manufacturer's symbols

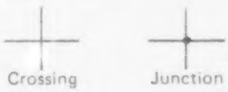
C. Aids in locating components

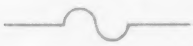
VII. Schematic symbols (Transparency 3)

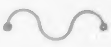
A. Capacitor 

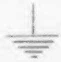
B. Coils 

C. Contacts 
Open
Closed

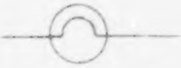
D. Conductors 
Crossing
Junction

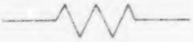
E. Fuse 

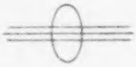
F. Fusible link 

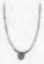
G. Ground connection 

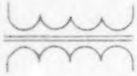
INFORMATION SHEET

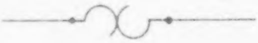
H. Light 

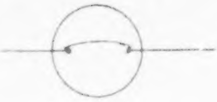
I. Resistor or resistance heater 

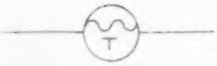
J. Multiple conductor cable 

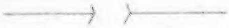
K. Thermocouple 

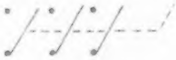
L. Transformer 

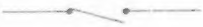
M. Thermal overload 

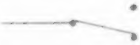
N. Bimetal switch 

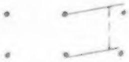
O. Thermistor 

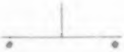
P. Connectors 

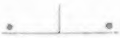
Q. Switches disconnect 

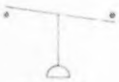
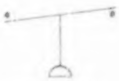
R. Single pole single throw (SPST) 

S. Single pole double throw (SPDT) 

T. Double pole double throw (DPDT) 

U. Push button (normally open) 

V. Push button (normally closed) 

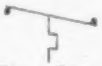
W. Pressure switches  

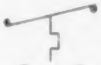
Close On Pressure Rise

Open On Pressure Rise

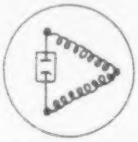
INFORMATION SHEET

X. Temperature switch

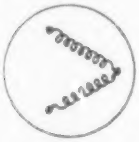

Close On Temperature Rise


Open On Temperature Rise

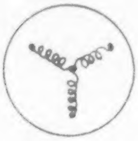
Y. Permanent split capacitor motor



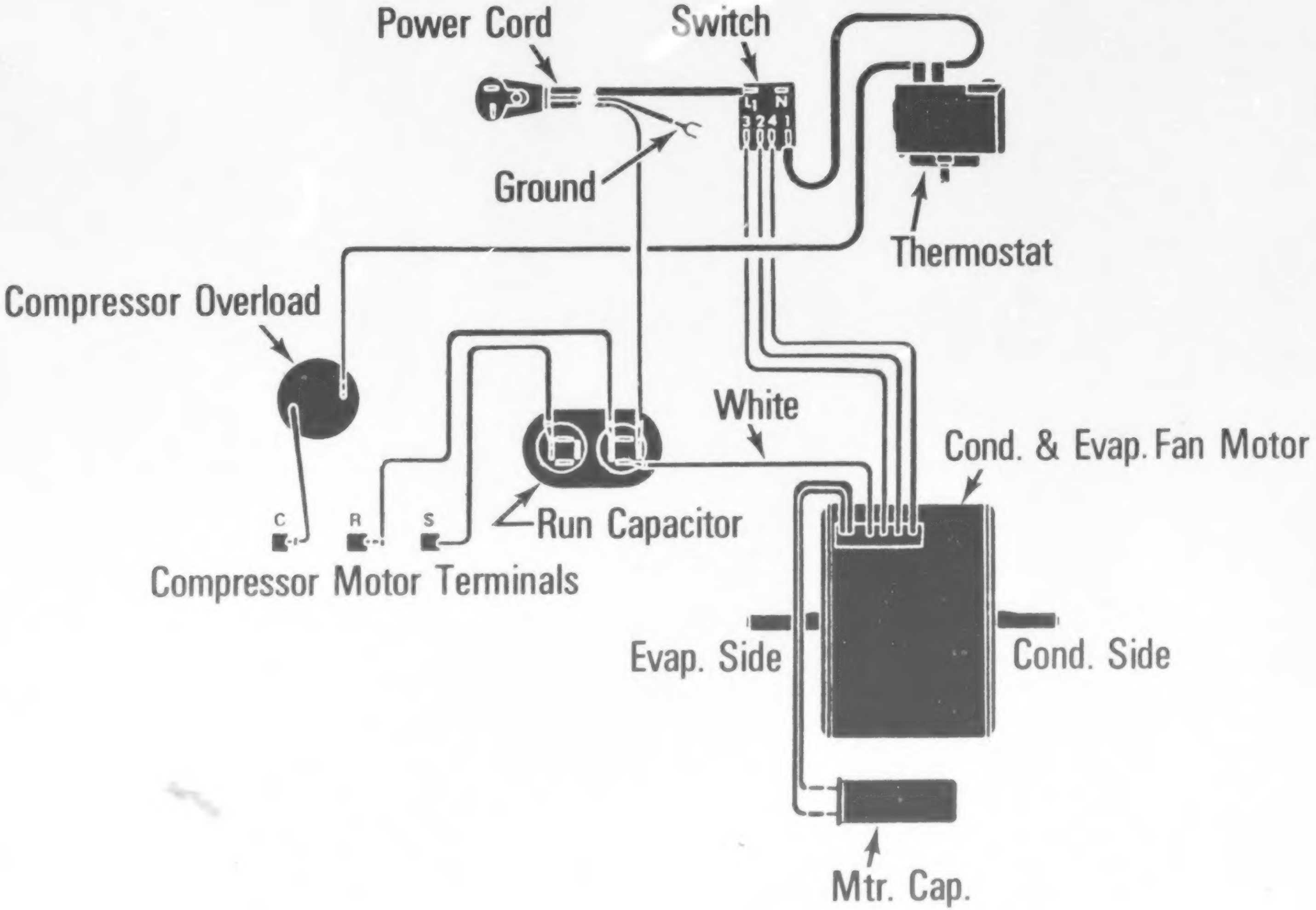
Z. Single-phase motor



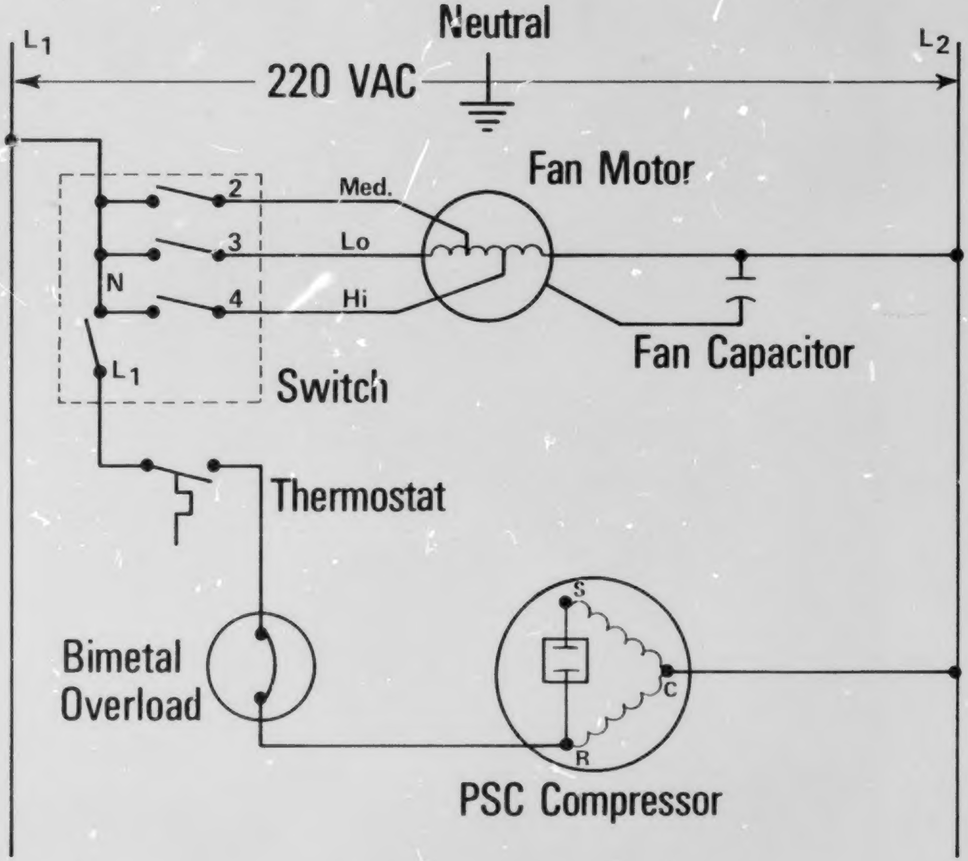
AA. Three-phase motor



Pictorial Wiring Diagram

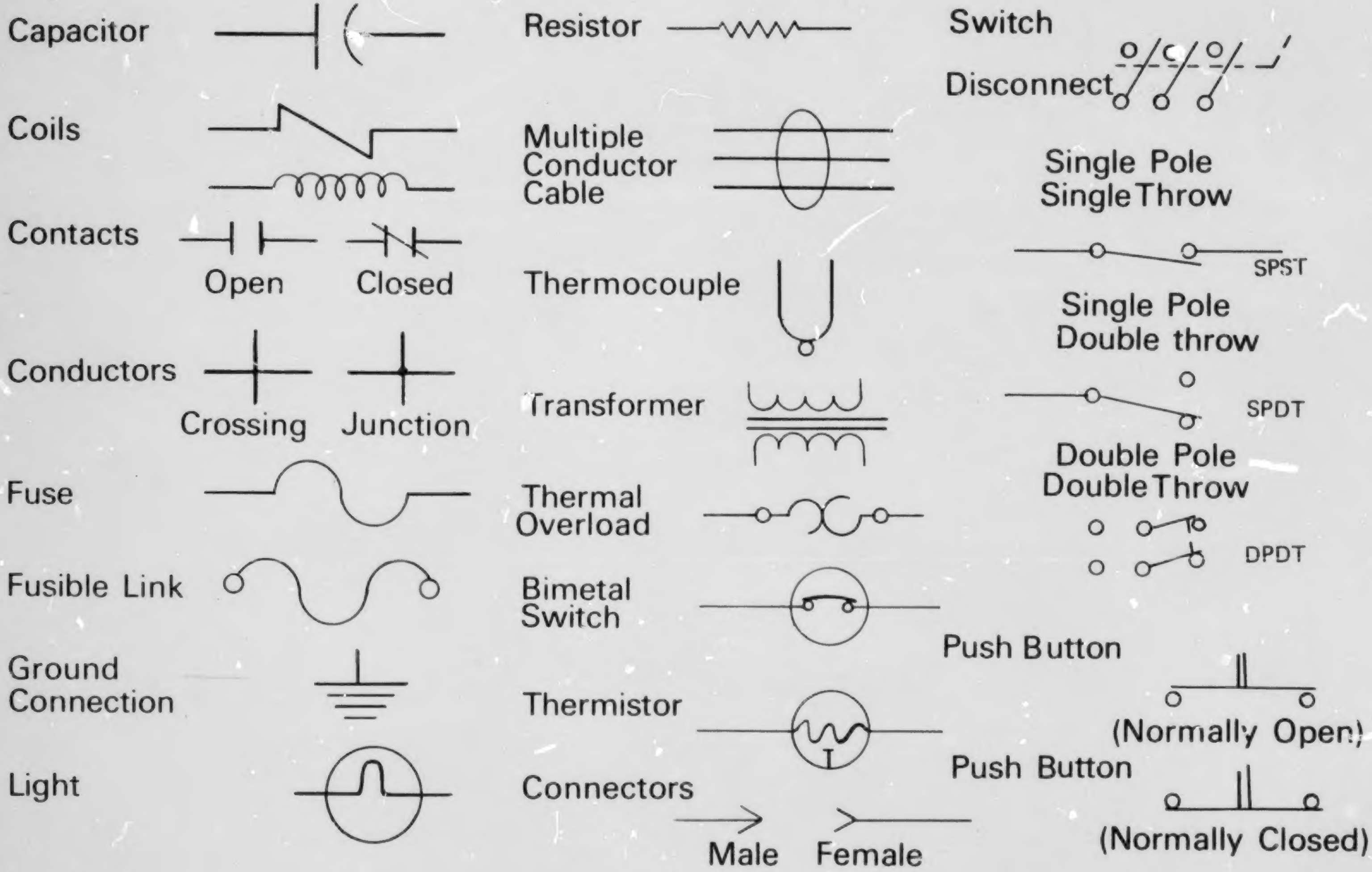

Power Cord
Switch
L1
N
3 2 4 1
Ground
Thermostat
Compressor Overload
White
Cond. & Evap. Fan Motor
C
R
S
Run Capacitor
Compressor Motor Terminals
Evap. Side
Cond. Side
Mtr. Cap.

Ladder Schematic Wiring Diagram


Neutral
L1
L2
220 VAC
Fan Motor
2
3
4
Med.
Lo
Hi
N
L1
Switch
Fan Capacitor
Thermostat
Bimetal Overload
S
C
R
PSC Compressor

TM 2

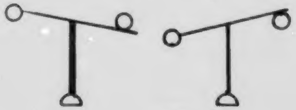
Symbols


Capacitor
Coils
Contacts
Open
Closed
Conductors
Crossing
Junction
Fuse
Fusible Link
Ground Connection
Light
Resistor
Multiple Conductor Cable
Thermocouple
Transformer
Thermal Overload
Bimetal Switch
Thermistor
Connectors
Male
Female
Switch
Disconnect
Single Pole Single Throw
SPST
Single Pole Double throw
SPDT
Double Pole Double Throw
DPDT
Push Button
(Normally Open)
Push Button
(Normally Closed)

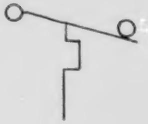
Symbols

(Continued)

Pressure

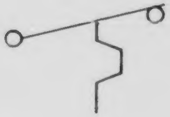


Temperature

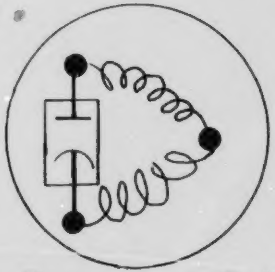


Close on Rising

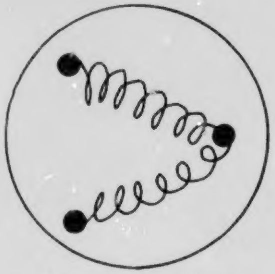
Temperature



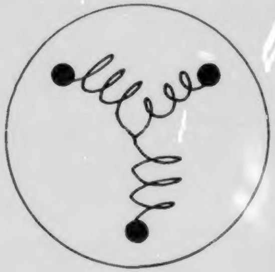
Open on Rising



Permanent Split Capacitor Motor



Single-Phase Motor



Three –Phase Compressor Motor

WIRING DIAGRAMS
UNIT I

ASSIGNMENT SHEET #1--DRAW A BASIC SCHEMATIC WIRING DIAGRAM

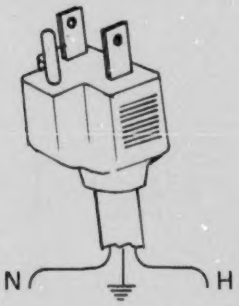
In the space provided below draw a schematic wiring diagram with the following components: 120 VAC fused power supply, three loads, two SPST switches, and one control relay with a line voltage coil. Each load is to be a parallel circuit, control two loads with the relay, one load with a SPST switch, and the relay coil with a SPST switch.

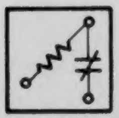
WIRING DIAGRAMS
UNIT I

ASSIGNMENT SHEET #2--DRAW CURRENT RELAY WIRING DIAGRAMS

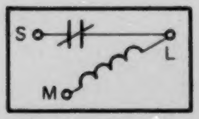
Follow the procedure listed to complete the pictorial wiring diagram below.

1. Connect thermostat in series with "L" on relay in the hot leg of the power supply.
2. Connect start capacitor in series between "S" on relay and "S" on compressor motor.
3. Connect overload in series between "C" on compressor motor and neutral leg of the power supply.

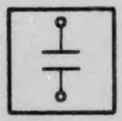




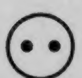
Bimetal Overload



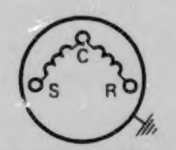
Current-Type Starting Relay



Cold Control (thermostat)



Starting Capacitor



Compressor Motor

ASSIGNMENT SHEET #2

4. In the space provided below draw a ladder schematic of the pictorial wiring diagram.

5. Identify all components.

WIRING DIAGRAMS
UNIT I

ASSIGNMENT SHEET #3--DRAW POTENTIAL RELAY WIRING DIAGRAMS OF A SELF-CONTAINED UNIT

Follow the procedure listed to complete the pictorial wiring diagram below.

1. Connect thermostat in series with contactor coil and a fuse.

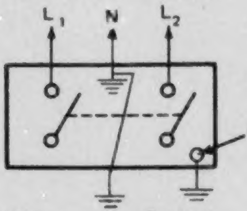
   (NOTE: Contactor coil is 120 VAC which requires using one leg of the 240 VAC (L_2) and neutral.)

   (CAUTION: All switches are to be in the hot leg.)

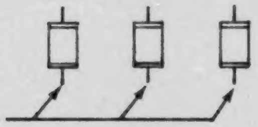
2. Connect power L_1 and L_2 to contactor L_1 and L_2 with fuses in series.
3. Connect T_1 to #3 on overload.
4. Connect #1 on overload to "C" on compressor motor.
5. Connect relay #5 to "C" on compressor motor.
6. Connect relay #2 to "S" on compressor motor.
7. Connect relay #1 to one side of start capacitor.
8. Connect other side of start capacitor to T_2.
9. Connect T_2 to "R" on compressor motor.
10. Connect run capacitor identified terminal to "R" on compressor motor.
11. Connect other side of run capacitor to "S" on compressor motor.

ASSIGNMENT SHEET #3

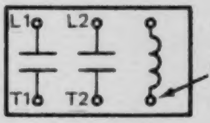
To Power Supply


L1
N
L2
Grounding Lug

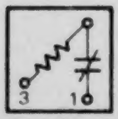
Disconnect Switch



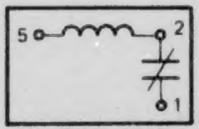
Fuse


L1
L2
T1
T2
120 VAC Coil

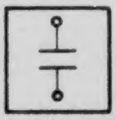
Contactor



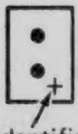
Overload



Starting Relay (Potential)

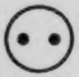


Cold Control (Thermostat)

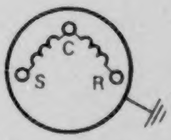


Running Capacitor

Identified Terminal



Starting Capacitor



Compressor Motor
230 VAC

ASSIGNMENT SHEET #3

12. In the space provided draw a ladder schematic of the pictorial wiring diagram.
13. Identify all components.

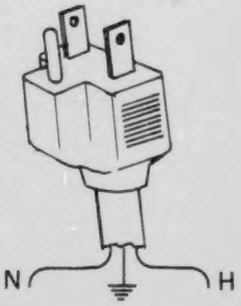
WIRING DIAGRAMS
UNIT I

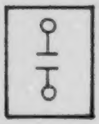
ASSIGNMENT SHEET #4--DRAW HOT-WIRE RELAY WIRING DIAGRAMS

Follow the procedure listed to complete the pictorial wiring diagram below.

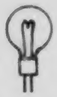
1. Connect thermostat in series with "L" on relay in the hot leg of the power supply.
2. Connect "S" on relay to "S" on compressor motor.
3. Connect "M" on relay to "R" on compressor motor.
4. Connect "C" on compressor motor to neutral.
5. Connect one side of door light switch to hot leg of power supply.
6. Connect other side of door light switch to one side of door light.
7. Connect other side of door light to neutral.

To Power Supply

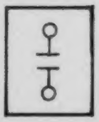




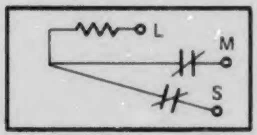
Doorlight Switch



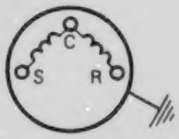
Door Light



Thermostat



Hot Wire Starting Relay



Compressor Motor

ASSIGNMENT SHEET #4

8. In the space provided below draw a ladder schematic of the pictorial wiring diagram.

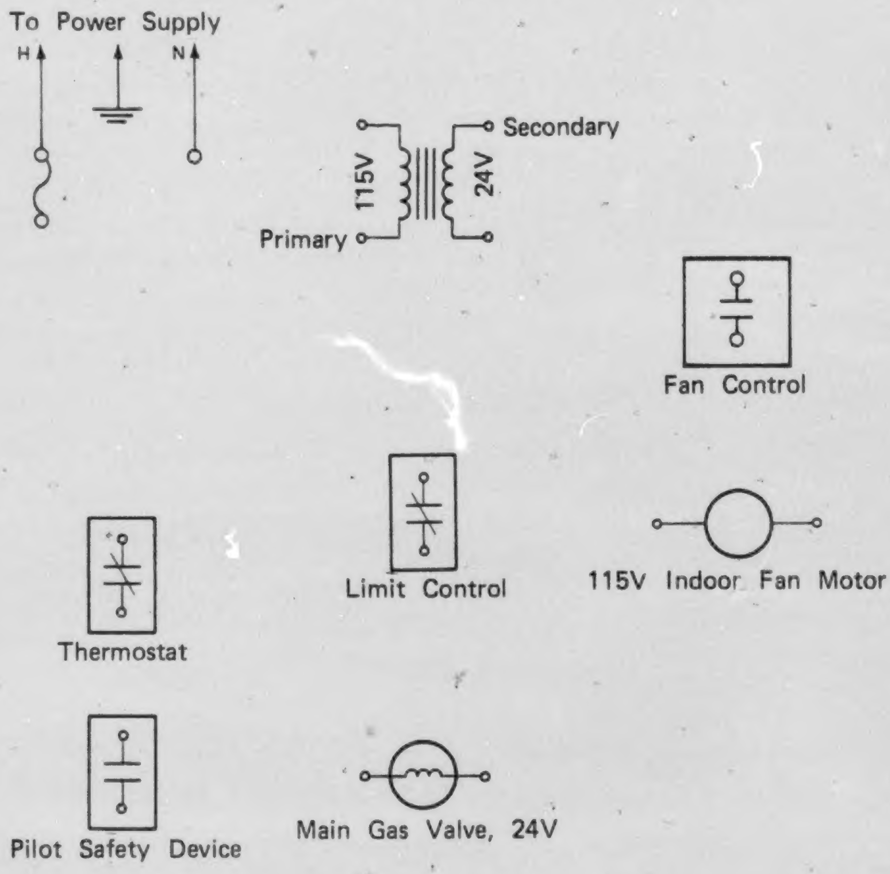
9. Identify all components.

WIRING DIAGRAMS
UNIT I

ASSIGNMENT SHEET #5--DRAW GAS FURNACE WIRING DIAGRAMS

Follow the procedure listed to complete the pictorial wiring diagram below.

1. Connect one lead of the transformers primary winding to the hot leg of the power supply.
2. Connect other side of transformer to neutral.
3. Connect one side of fan control to hot leg of power supply.
4. Connect other side of fan control to one side of fan motor.
5. Connect other side of fan motor to neutral.
6. Connect the limit control, thermostat, pilot safety device, and main gas valve in a series circuit with the secondary of the transformer.


To Power Supply
H
N
Secondary
115V
24V
Primary
Fan Control
Limit Control
115V Indoor Fan Motor
Thermostat
Pilot Safety Device
Main Gas Valve, 24V

ASSIGNMENT SHEET #5

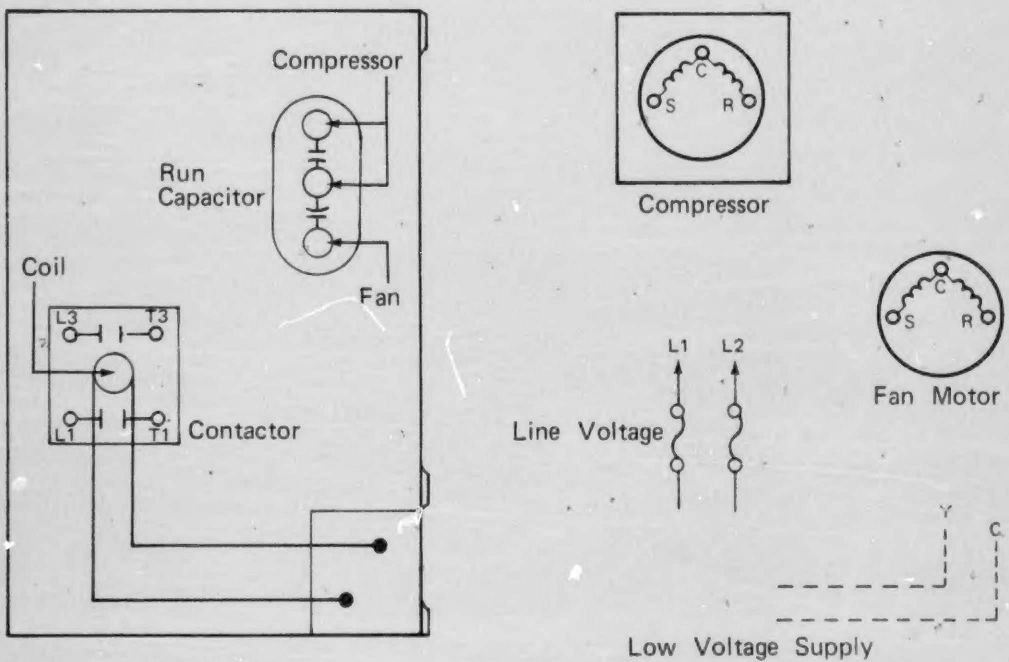
7. In the space provided draw a ladder schematic of the pictorial wiring diagram.
8. Identify all components.

WIRING DIAGRAMS
UNIT I

ASSIGNMENT SHEET #6--DRAW OUTDOOR CONDENSING UNIT WIRING DIAGRAMS

Follow the procedure listed to complete the pictorial wiring diagram below.

1. Connect "Y" and "C" to low voltage supply for coil, using dotted lines.
2. Connect fused L_1 to L_1 on contactor.
3. Connect fused L_2 to L_3 on contactor.
4. Connect T_1 to common on run capacitor.
5. Connect T_3 to "C" on fan motor and "C" on compressor motor.
6. Connect common on run capacitor to "R" on fan motor and to "R" on compressor motor.
7. Connect the "comp." terminal on the run capacitor to "S" on compressor motor.
8. Connect the fan terminal on the run capacitor to "S" on fan motor.


Compressor
Run Capacitor
Coil
Fan
L3
T3
L1
T1
Contactor
C
S
R
Compressor
L1
L2
Line Voltage
C
S
R
Fan Motor
Y
C
Low Voltage Supply

ASSIGNMENT SHEET #6

9. In the space provided draw a ladder schematic of the pictorial wiring diagram.

10. Identify all components.

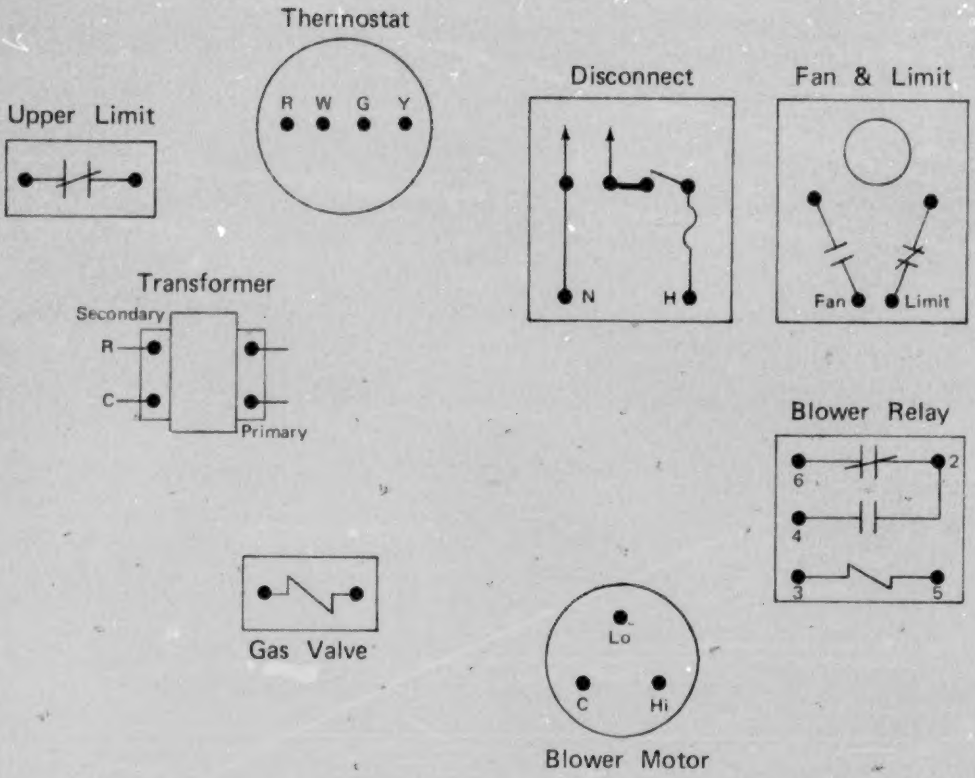
WIRING DIAGRAMS
UNIT I

ASSIGNMENT SHEET #7--DRAW GAS FURNACE WIRING DIAGRAMS WITH TWO LIMIT SWITCHES

Follow the procedure listed to complete the pictorial wiring diagram on the following page.

1. Connect one lead of the transformer primary in series with the upper limit control and the hot leg of the power supply.
2. Connect the other lead of the transformer primary to neutral.
3. Connect "R" on transformer secondary to "R" on thermostat.
4. Connect "W" on thermostat to one side of limit control in fan and limit combination.
5. Connect other side of limit to one side of gas valve.
6. Connect other side of gas valve to "C" on transformer secondary.
7. Connect "G" on thermostat to #3 of blower relay coil.
8. Connect #5 of relay coil to "C" on transformer secondary.
9. Connect #2 of relay to hot leg of power supply.
10. Connect #6 of relay to fan switch contacts in fan-limit switch.
11. Connect other side of (N.O.) fan switch to "Lo" on blower motor.
12. Connect #4 of relay to "Hi" on blower motor.
13. Connect "C" on blower motor to neutral.

ASSIGNMENT SHEET #7


Thermostat
R
W
G
Y
Upper Limit
Disconnect
N
H
Fan & Limit
Fan
Limit
Transformer
Secondary
R
C
Primary
Blower Relay
6
2
4
3
5
Gas Valve
Lo
C
Hi
Blower Motor

ASSIGNMENT SHEET #7

14. In the space provided draw a ladder schematic of the pictorial wiring diagram.

15. Identify all components.

WIRING DIAGRAMS
UNIT I

ASSIGNMENT SHEET #8--DRAW ELECTRIC FURNACE WIRING DIAGRAMS

Follow the procedure listed to complete the pictorial wiring diagram on the following page.

1. Connect L_1 of circuit 1 to one side of fuse 1.
2. Connect other side of fuse 1 to #2 of blower relay.
3. Connect #6 of blower relay to one side of the supplementary fan control.
4. Connect other side of supplementary fan control to "L" on blower motor.
5. Connect #4 of blower relay to "H" of blower motor.
6. Connect "C" of blower motor to fuse 2.
7. Connect fuse 2 to L_2 of circuit 1.
8. Connect fuse 2 to RH1 of sequencer.
9. Connect RH1 of sequencer to RH1 of heating element.
10. Connect other side of RH1 heating element to fuse 1.
11. Connect fuse 3 to L_1 of circuit 2.
12. Connect other side of fuse 3 to RH2 of sequencer.
13. Connect RH2 of sequencer to RH2 heating element.
14. Connect other side of RH2 heating element to fuse 4.
15. Connect fuse 4 to L_2 of circuit 2.
16. Connect fuse 4 to one side of auxilliary contacts of sequencer.
17. Connect other side of auxilliary contacts to one side of RH3 heating element.
18. Connect other side of RH3 heating element to fuse 3.
19. Connect L_1 and L_2 of transformer to fuses 1 and 2.
20. Connect "C" on transformer to "C" on terminal board.
21. Connect "R" on transformer to "R" on terminal board.

ASSIGNMENT SHEET #8

22. Connect all corresponding letters between thermostat and terminal board.

23. Connect W1 on terminal board to one side of Heater 1 of sequencer.

24. Connect other side of Heater 1 to "C" on terminal board.

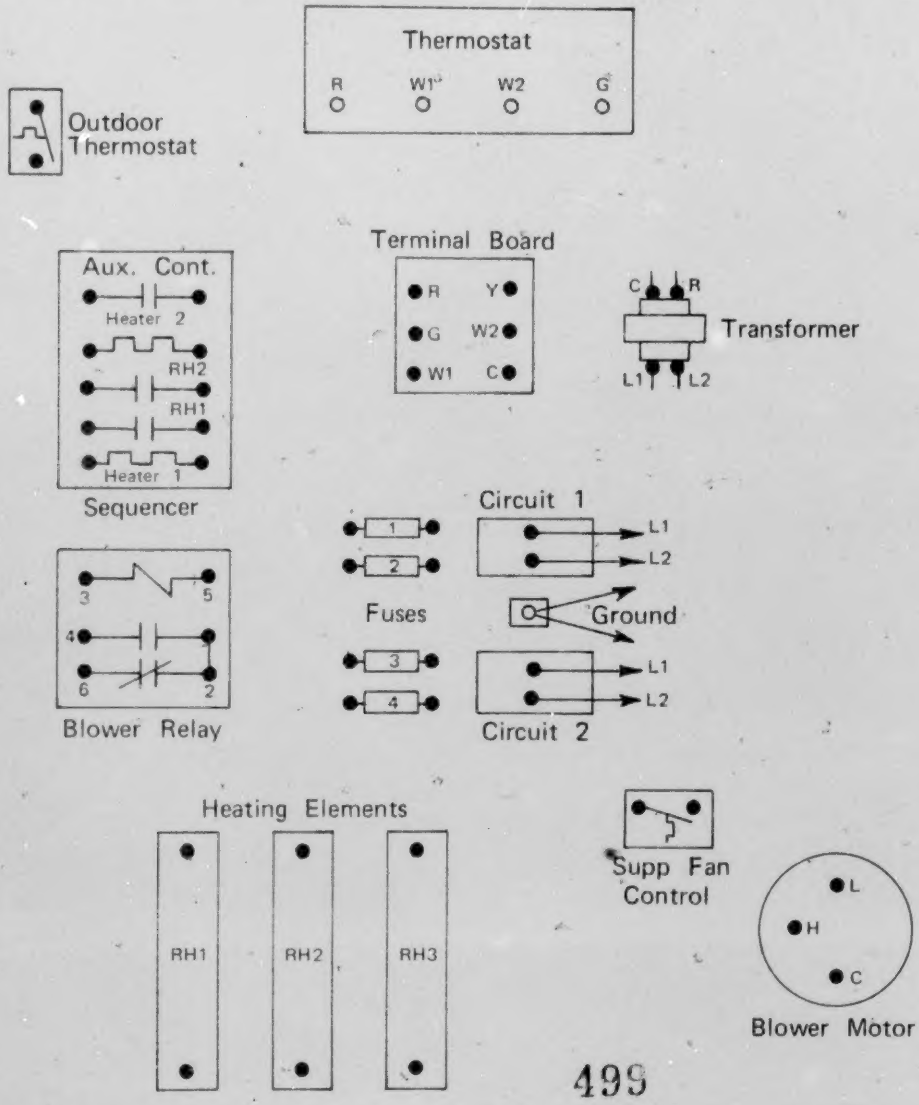
25. Connect W2 on terminal board to one side of Heater 2 on sequencer.

26. Connect other side of sequencer Heater 2 to one side of outdoor thermostat.

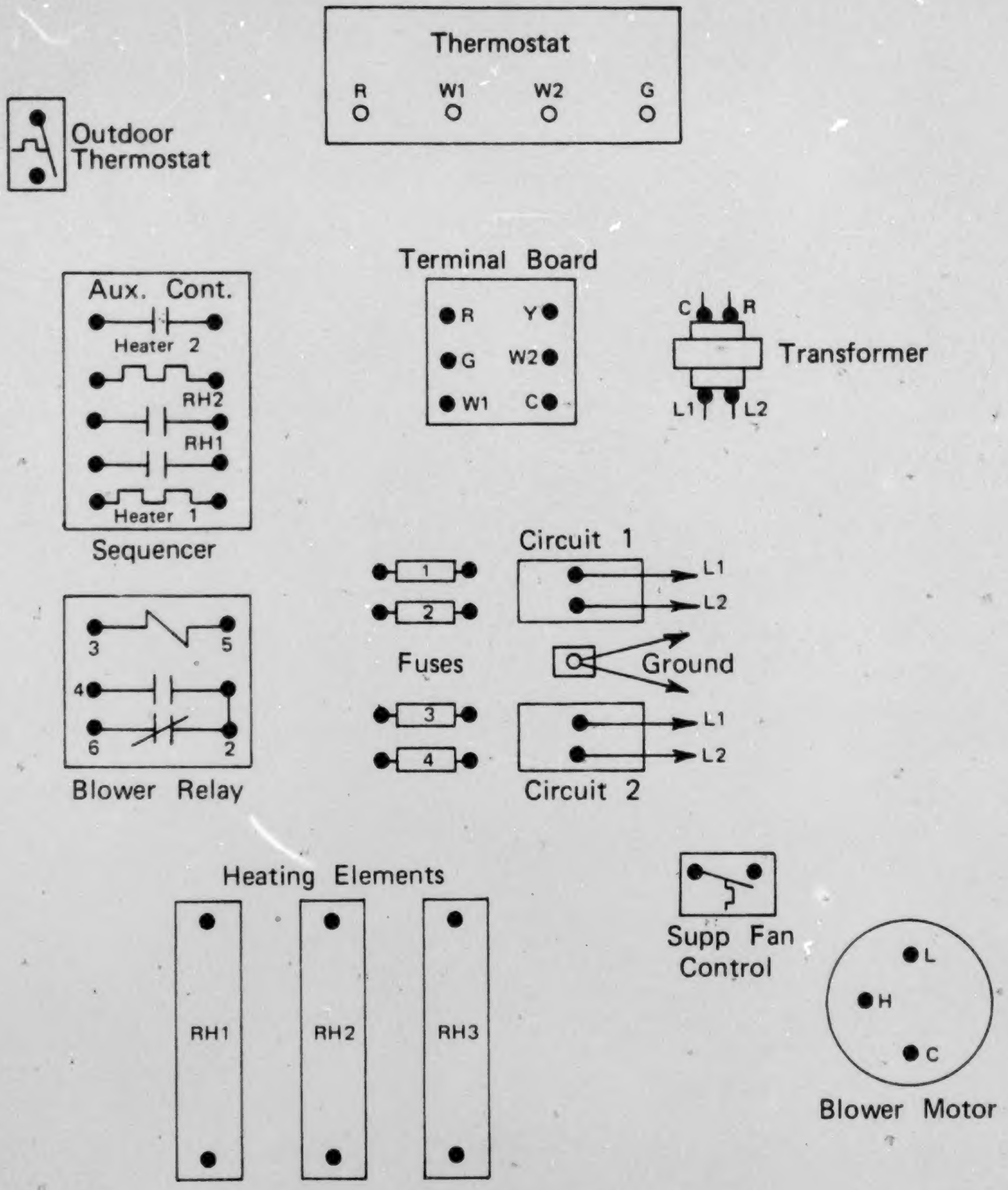
27. Connect other side of outdoor thermostat to "C" on terminal board.

28. Connect "G" on terminal board to #5 on blower relay.

29. Connect #3 on blower relay to "C" on terminal board.


Thermostat
R
W1
W2
G
Outdoor Thermostat
Terminal Board
R
Y
G
W2
W1
C
C
R
Transformer
L1
L2
Aux. Cont.
Heater 2
RH2
RH1
Heater 1
Sequencer
3
5
4
6
2
Blower Relay
1
2
Fuses
3
4
Circuit 1
L1
L2
Ground
L1
L2
Circuit 2
Heating Elements
RH1
RH2
RH3
Supp Fan Control
L
H
C
Blower Motor

ASSIGNMENT SHEET #8


Thermostat
R
W1
W2
G
Outdoor Thermostat
Terminal Board
R
Y
G
W2
W1
C
C
R
Transformer
L1
L2
Aux. Cont.
Heater 2
RH2
RH1
Heater 1
Sequencer
Circuit 1
L1
L2
1
2
Fuses
Ground
3
4
L1
L2
Circuit 2
3
5
4
6
2
Blower Relay
Heating Elements
RH1
RH2
RH3
Supp Fan Control
L
H
C
Blower Motor

ASSIGNMENT SHEET #8

30. In the space provided draw a ladder schematic of the pictorial wiring diagram.

31. Identify all components.

WIRING DIAGRAMS
UNIT I

ASSIGNMENT SHEET #9--DRAW INDOOR AIR HANDLER AND OUTDOOR CONDENSING UNIT WIRING DIAGRAM

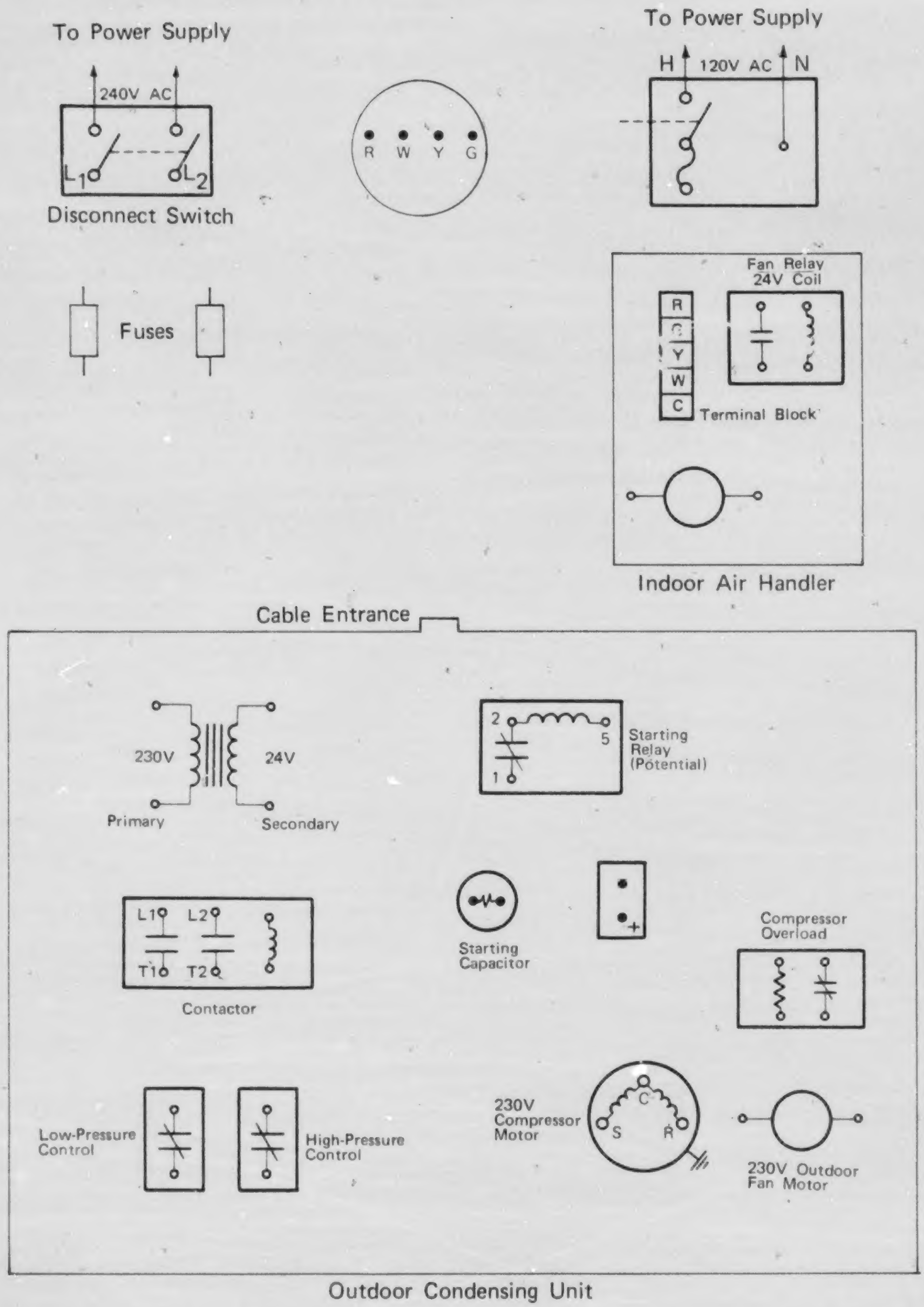
Follow the procedure listed to complete the pictorial wiring diagram on the following page.

1. Connect L_1 and L_2 to fuses.
2. Route power leads from fuses through the cable entrance opening in outdoor condensing unit.
3. Connect leads to L_1 and L_2 of contactor.
4. Connect primary side of transformer to L_1 and L_2 on contactor.
5. Connect T_2 to one side of compressor motor overload heater.
6. Connect other side of overload heater to "R" on compressor motor.
7. Connect T_1 to "C" on compressor motor.
8. Connect one side of outdoor fan motor to T_1.
9. Connect other side of fan motor to T_2.
10. Connect one side of start capacitor to #1 on potential relay.
11. Connect other side of start capacitor to T_2.
12. Connect #2 of potential relay to "S" on compressor motor.
13. Connect identified terminal of run capacitor to "R" on compressor motor.
14. Connect other side of run capacitor to "S" on compressor motor.
15. Connect #5 of potential relay to "C" on compressor motor.
16. Connect all corresponding letters between thermostat and terminal block.
17. Connect one side of the transformer secondary to "R" on terminal block.
18. Connect other side of the transformer secondary to "C" on terminal block.
19. Connect "Y" on terminal block to contactor coil, and place overload, high-pressure, low-pressure contacts in series with contactor coil.
20. Connect other side of contactor coil to "C" on terminal block.

ASSIGNMENT SHEET #9

21. Connect "G" on terminal block to one side of fan relay coil.
22. Connect other side of fan relay coil to "C" on terminal block.
23. Connect one side of fan relay contacts to hot leg of power supply.
24. Connect other side of fan relay contacts to one side of indoor fan motor.
25. Connect other side of indoor fan motor to neutral.

ASSIGNMENT SHEET #9


To Power Supply
240V AC
L1
L2
Disconnect Switch
R
W
Y
G
To Power Supply
H
120V AC
N
Fuses
Fan Relay
24V Coil
R
G
Y
W
C
Terminal Block
Indoor Air Handler
Cable Entrance
230V
24V
Primary
Secondary
2
5
1
Starting
Relay
(Potential)
L1
L2
T1
T2
Contactor
Starting
Capacitor
+
Compressor
Overload
Low-Pressure
Control
High-Pressure
Control
230V
Compressor
Motor
C
S
R
230V Outdoor
Fan Motor
Outdoor Condensing Unit

ASSIGNMENT SHEET #9

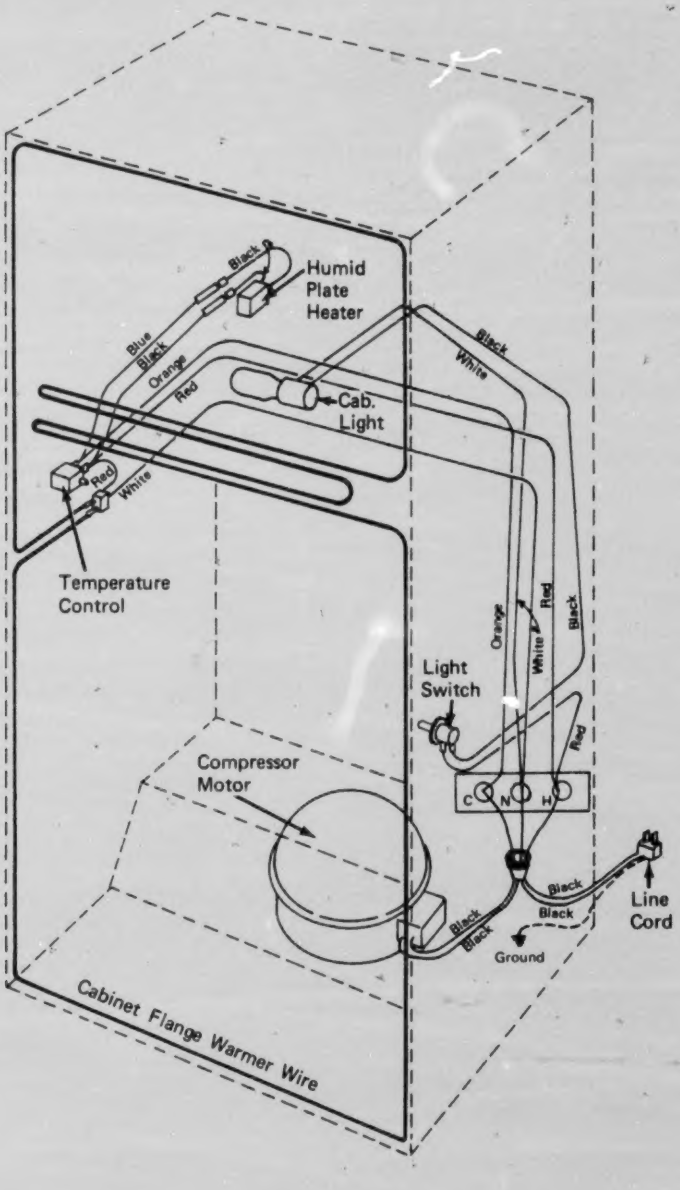
26. In the space provided draw a ladder schematic of the pictorial wiring diagram.

27. Identify all components.

WIRING DIAGRAMS
UNIT I

ASSIGNMENT SHEET #10--DRAW A DOMESTIC REFRIGERATOR WIRING DIAGRAM

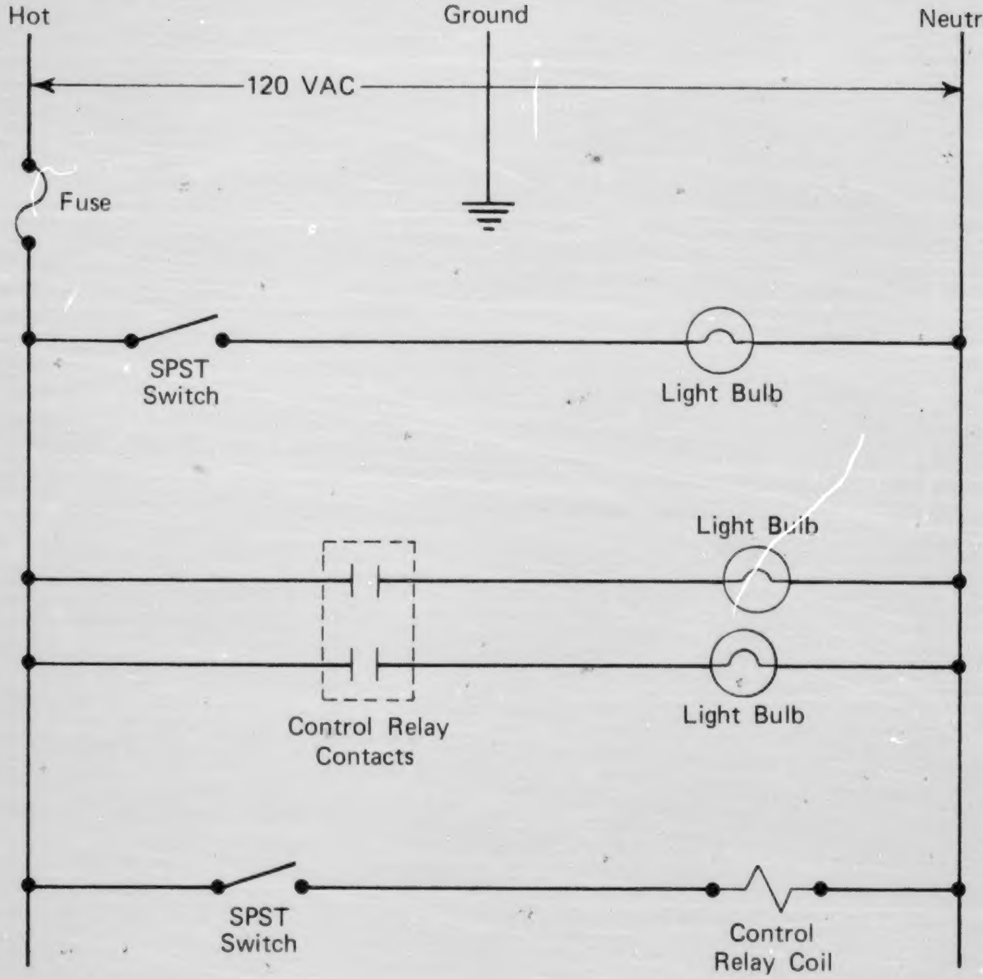
Use the pictorial wiring diagram of domestic refrigerator and draw a ladder schematic wiring diagram.


Black
Humid
Plate
Heater
Blue
Black
Orange
Red
Cab.
Light
Black
White
Red
White
Temperature
Control
Orange
White
Red
Black
Light
Switch
Red
C
N
H
Compressor
Motor
Black
Black
Black
Black
Ground
Line
Cord
Cabinet Flange Warmer Wire

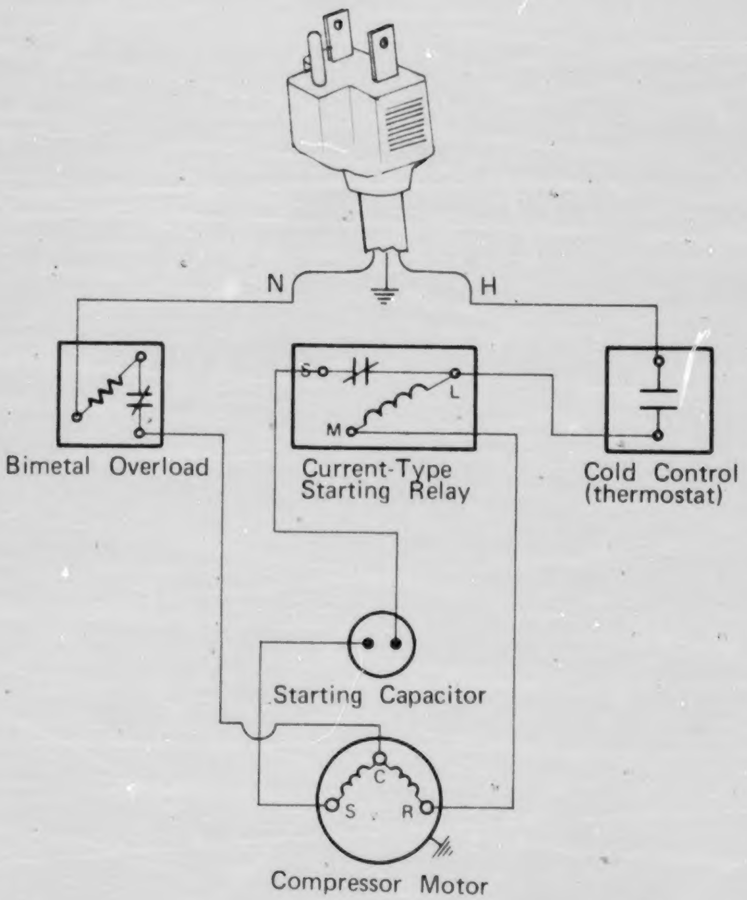
WIRING DIAGRAMS
UNIT I

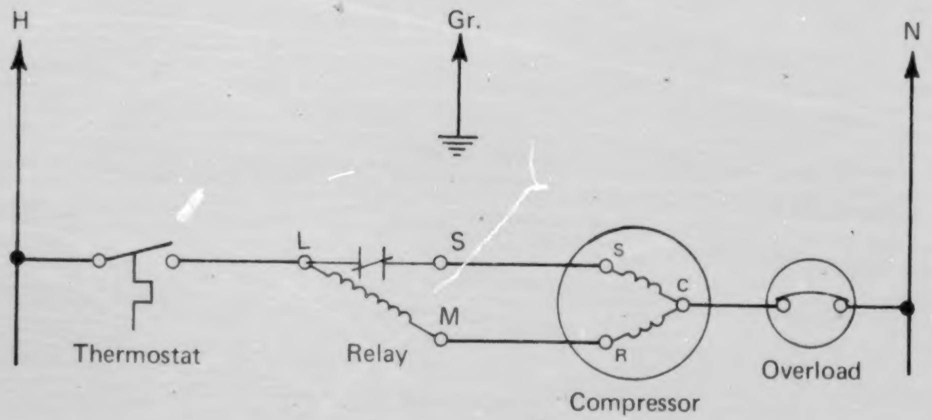
ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

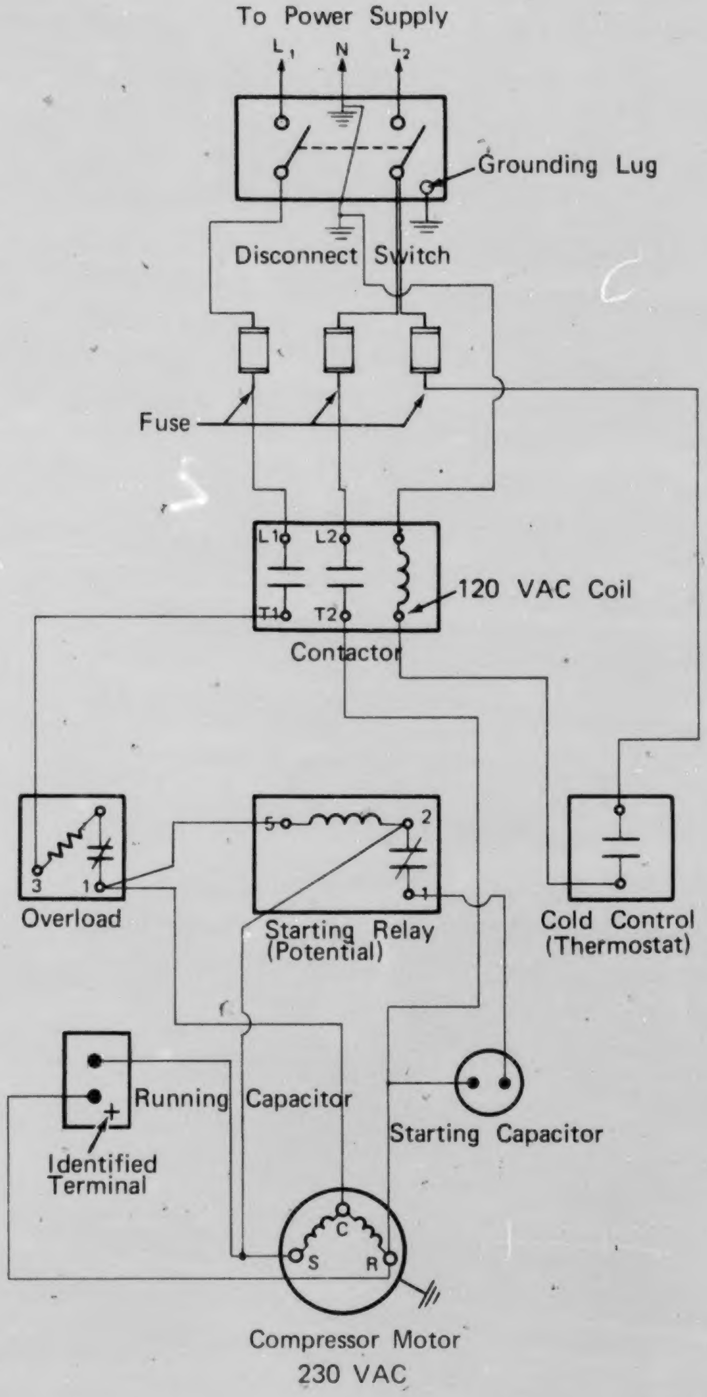

Hot
Ground
Neutral
120 VAC
Fuse
SPST Switch
Light Bulb
Light Bulb
Light Bulb
Control Relay Contacts
SPST Switch
Control Relay Coil

Assignment Sheet #2

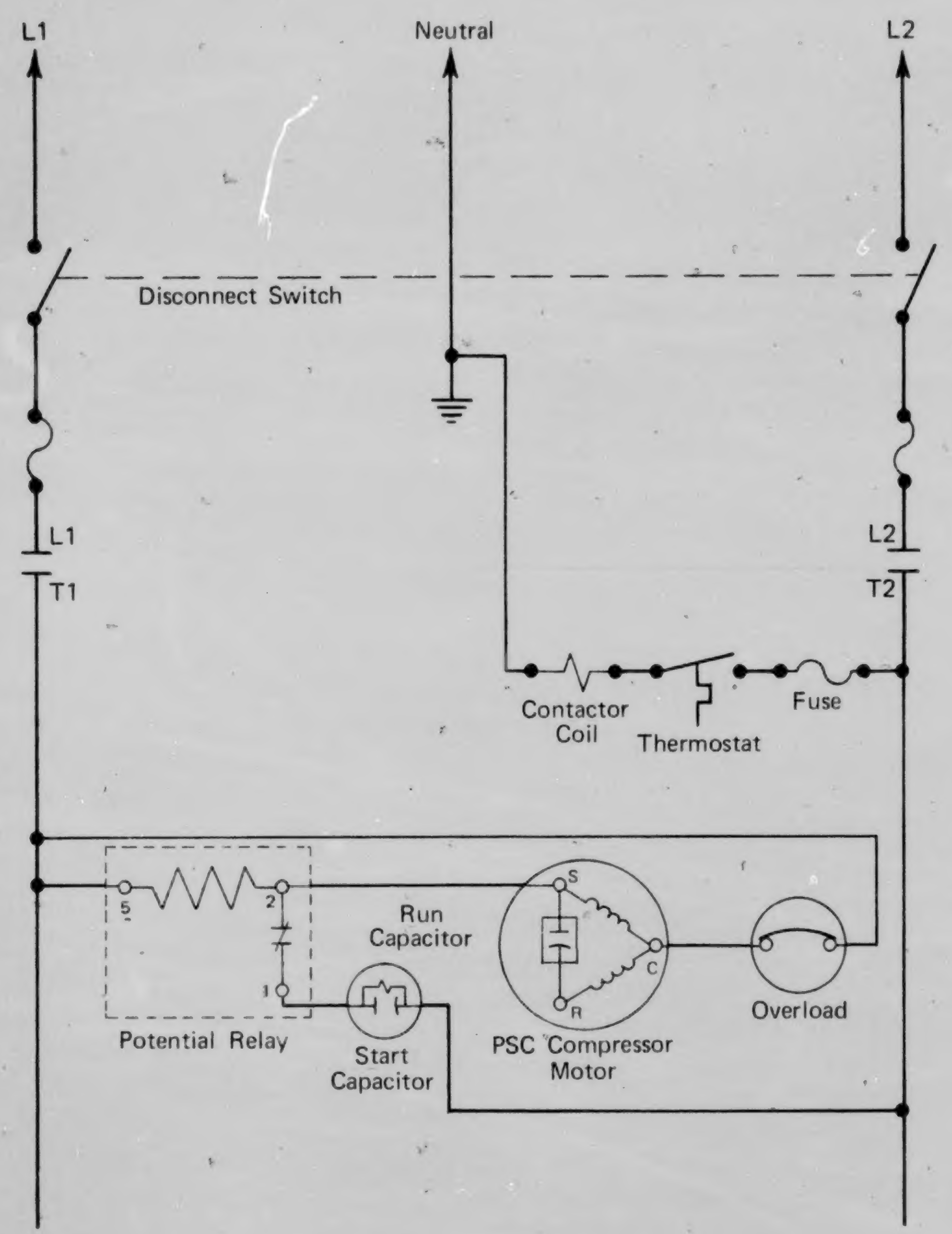

N
H
S
L
M
Bimetal Overload
Current-Type Starting Relay
Cold Control (thermostat)
Starting Capacitor
C
S
R
Compressor Motor


H
Gr.
N
L
S
M
Thermostat
Relay
S
C
R
Compressor
Overload

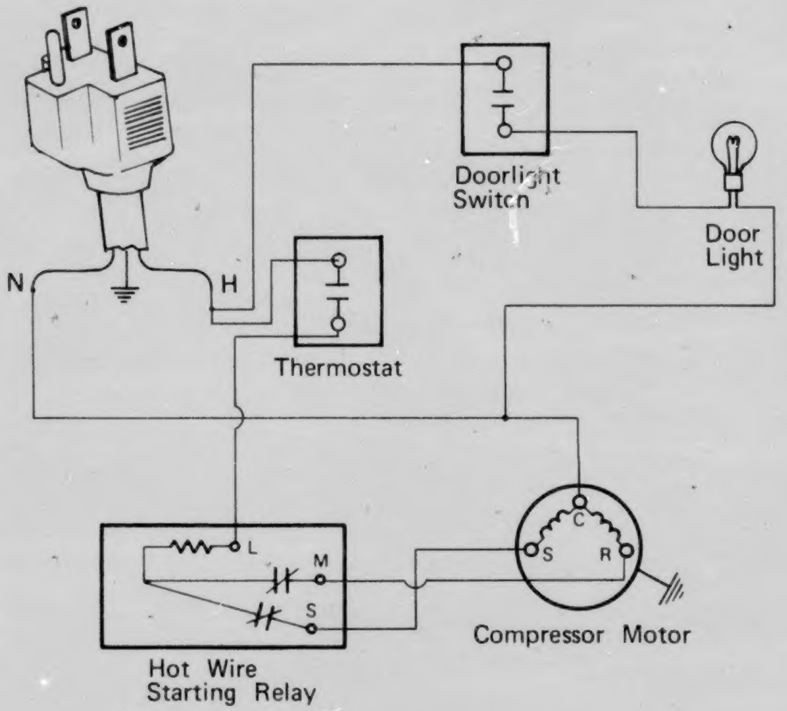
Assignment Sheet #3

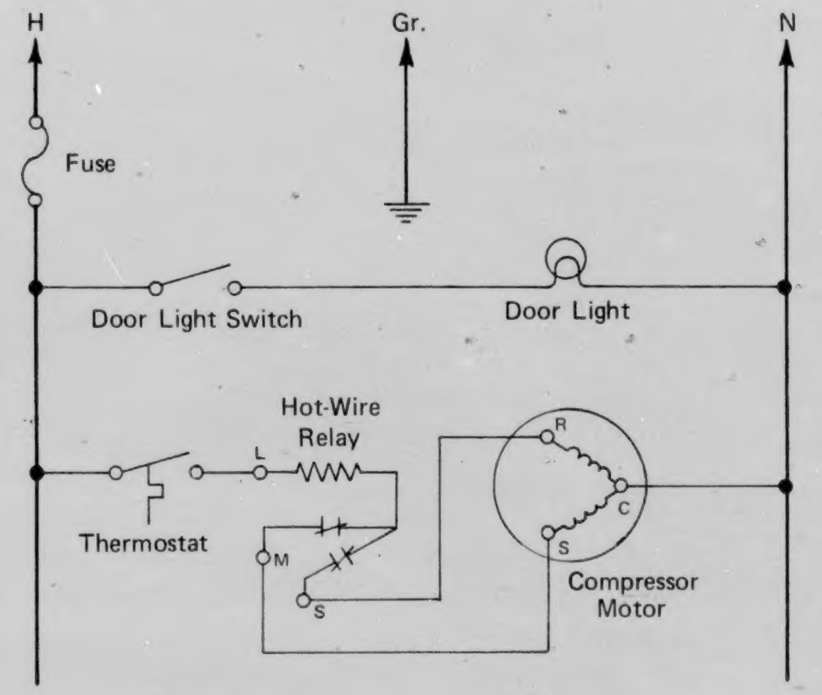

To Power Supply
L1
N
L2
Grounding Lug
Disconnect Switch
Fuse
L1
L2
T1
T2
120 VAC Coil
Contactor
5
2
3
1
1
Overload
Starting Relay (Potential)
Cold Control (Thermostat)
Running Capacitor
+
Identified Terminal
Starting Capacitor
C
S
R
Compressor Motor
230 VAC

Assignment Sheet #3 (continued)

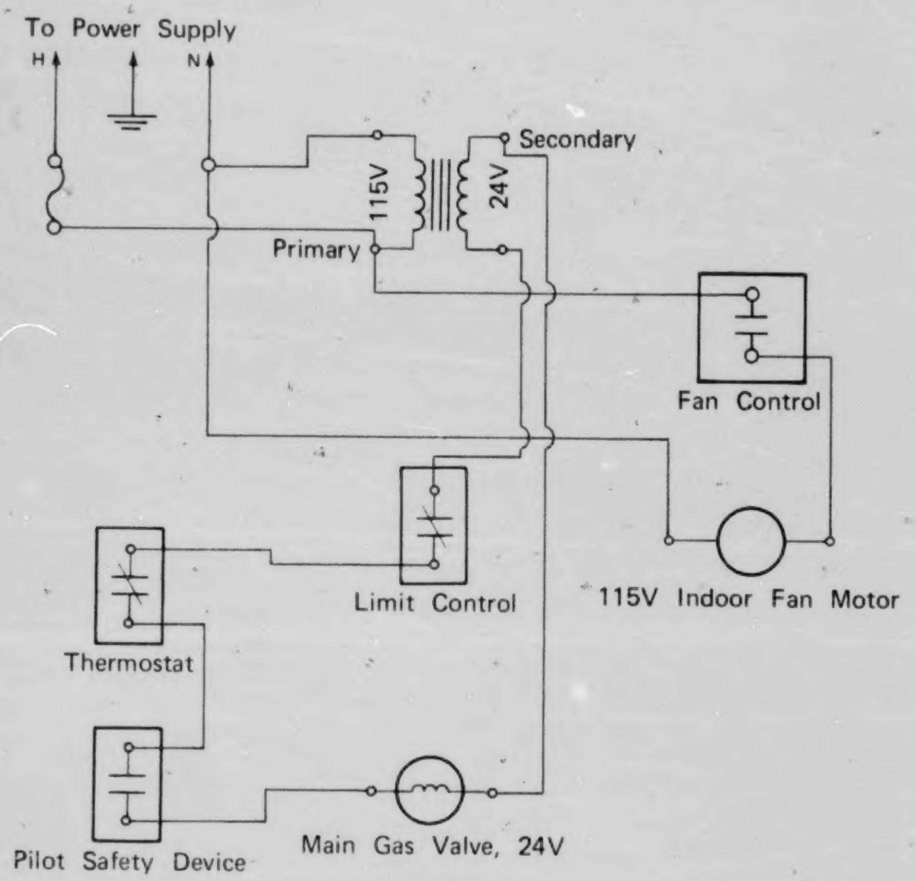

L1
Neutral
L2
Disconnect Switch
L1
T1
L2
T2
Contactor
Coil
Thermostat
Fuse
5
2
1
Potential Relay
Run
Capacitor
Start
Capacitor
S
C
R
PSC Compressor
Motor
Overload

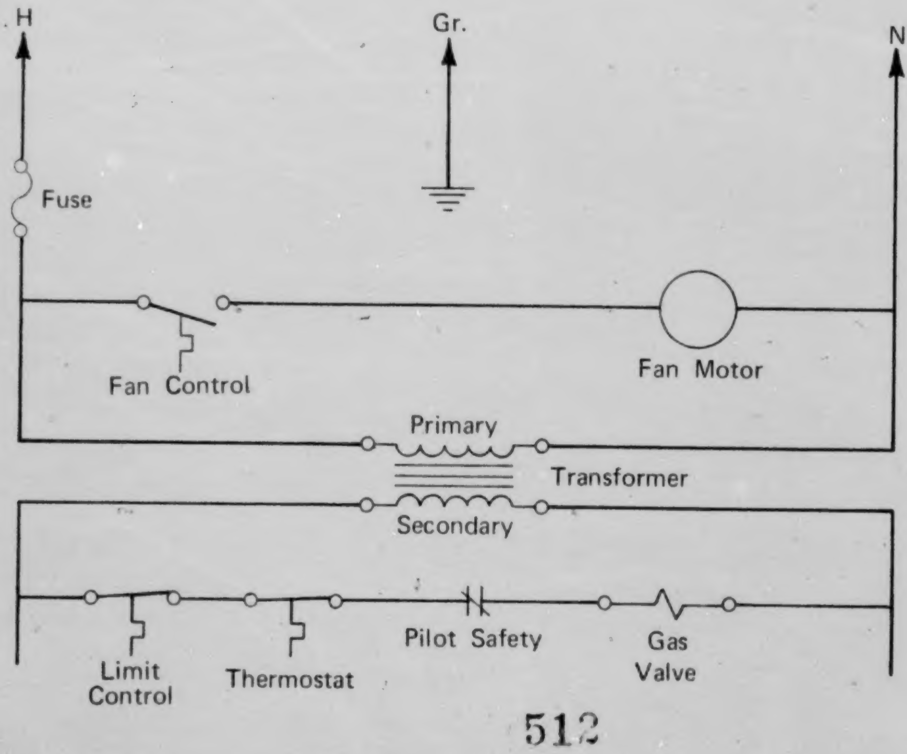
Assignment Sheet #4


Doorlight Switch
Door Light
N
H
Thermostat
L
M
S
C
S
R
Compressor Motor
Hot Wire Starting Relay

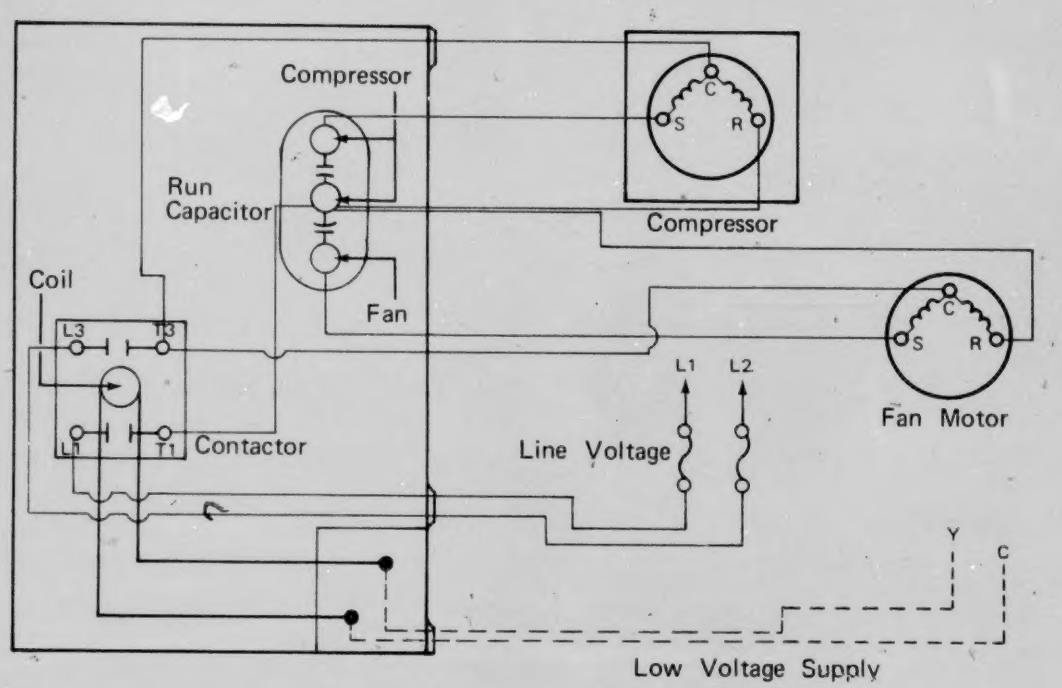

H
Gr.
N
Fuse
Door Light Switch
Door Light
Hot-Wire Relay
L
R
C
Thermostat
M
S
S
Compressor Motor

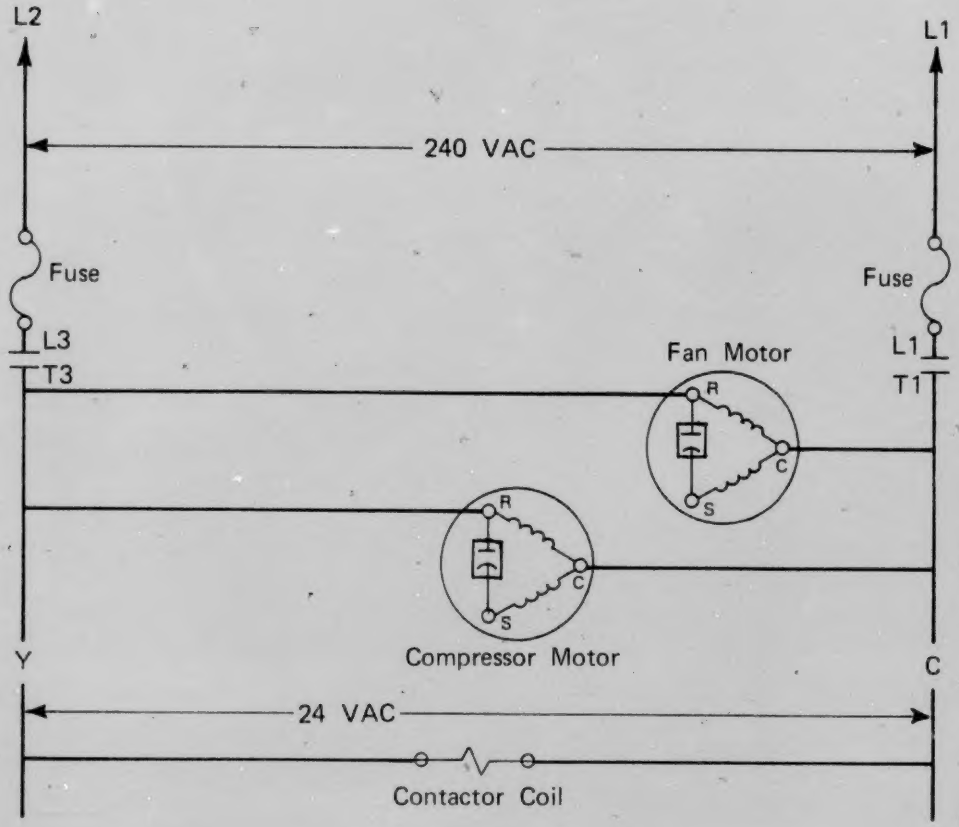
Assignment Sheet #5


To Power Supply
H
N
Secondary
115V
24V
Primary
Fan Control
115V Indoor Fan Motor
Limit Control
Thermostat
Pilot Safety Device
Main Gas Valve, 24V

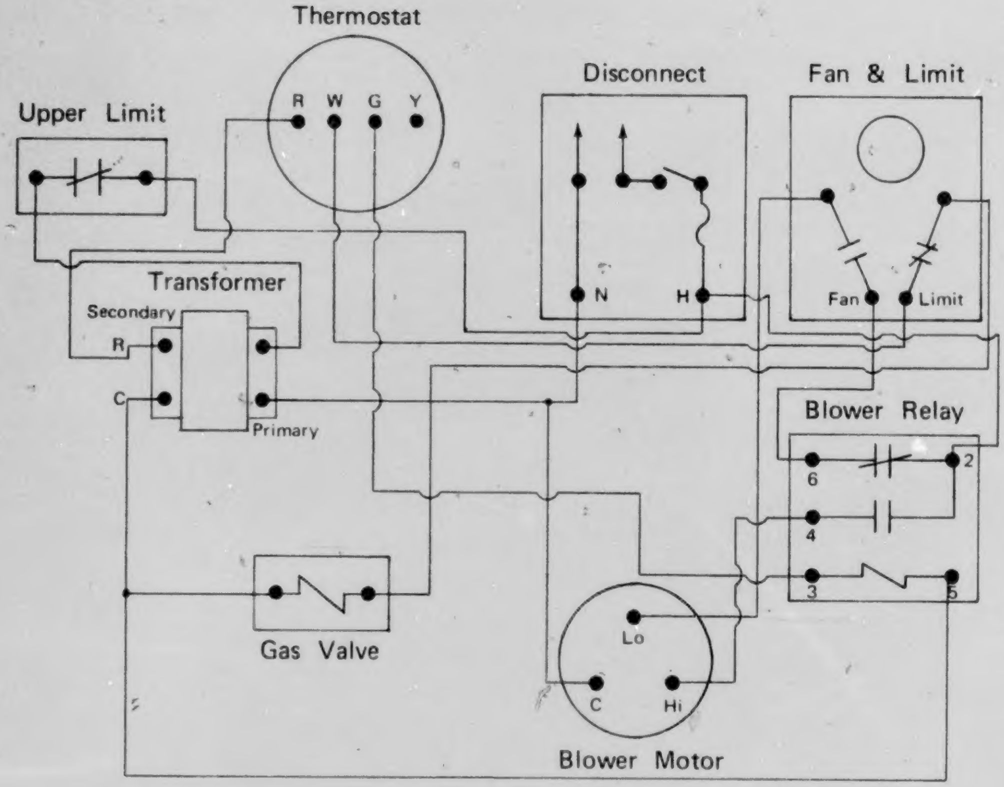

H
Gr.
N
Fuse
Fan Control
Fan Motor
Primary
Transformer
Secondary
Limit Control
Thermostat
Pilot Safety
Gas Valve

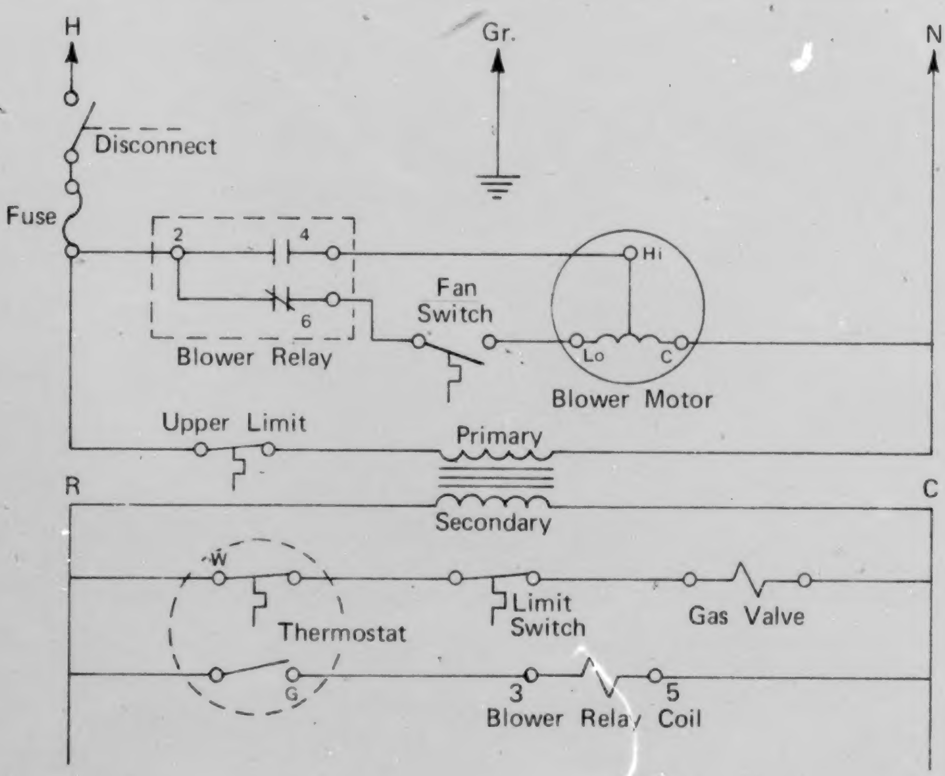
Assignment Sheet #6


Compressor
Run
Capacitor
Fan
Coil
L3
T3
L1
T1
Contactor
C
S
R
Compressor
C
S
R
Fan Motor
L1
L2
Line Voltage
Y
C
Low Voltage Supply

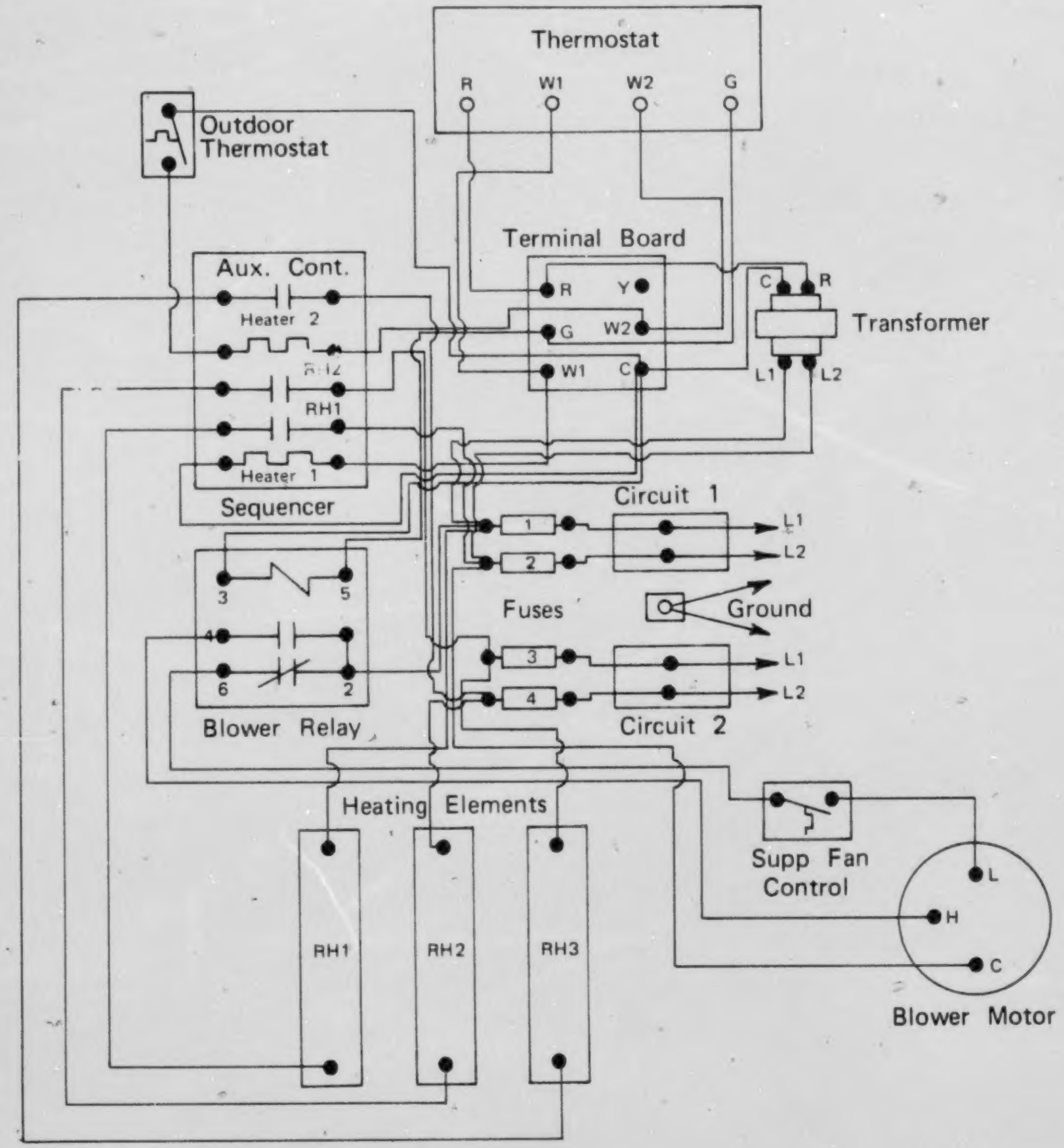

L2
L1
240 VAC
Fuse
Fuse
L3
T3
L1
T1
Fan Motor
R
C
S
R
C
S
Compressor Motor
Y
C
24 VAC
Contactor Coil

Assignment Sheet #7

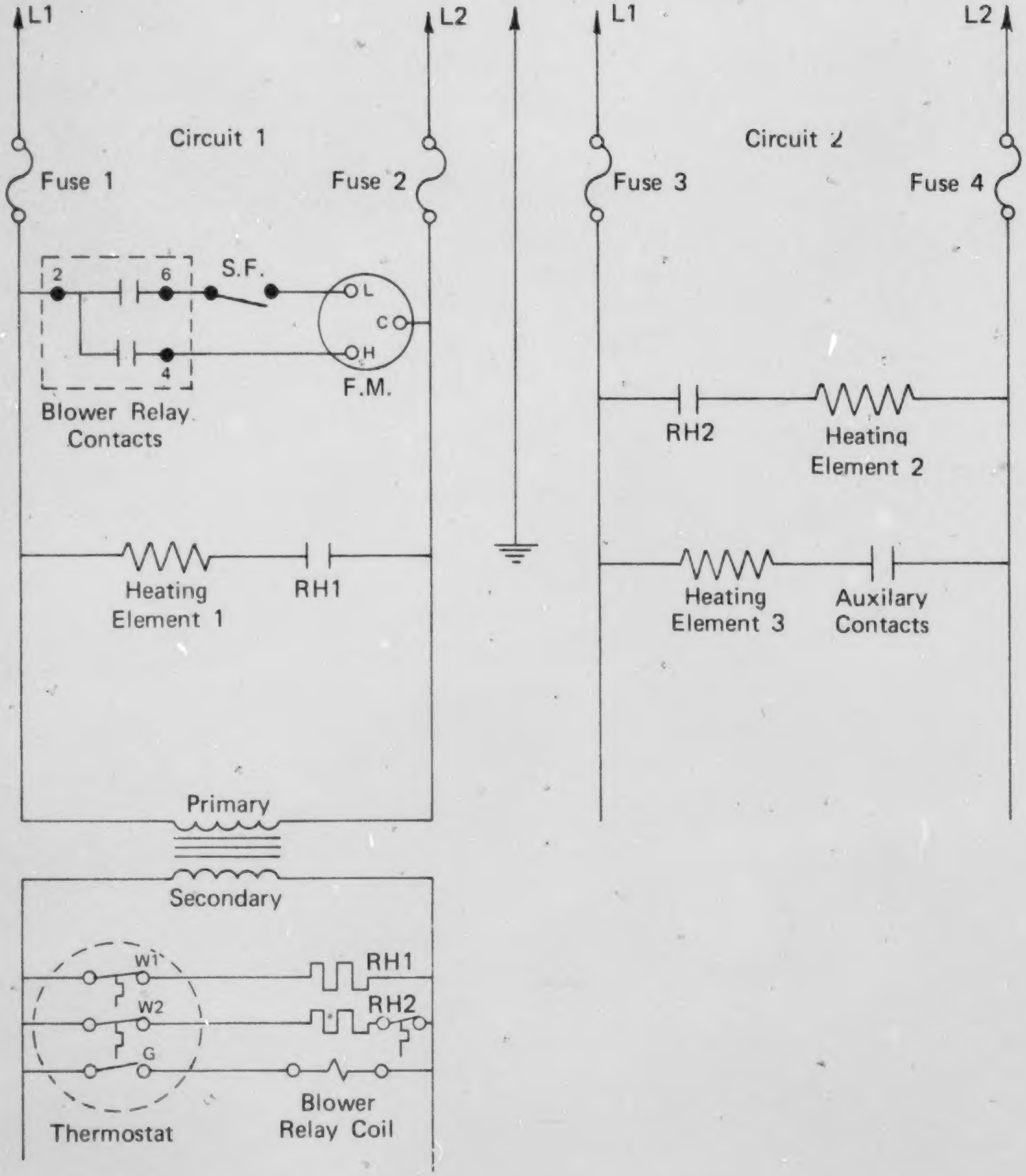

Thermostat
R
W
G
Y
Disconnect
Fan & Limit
Upper Limit
N
H
Fan
Limit
Transformer
Secondary
R
C
Primary
Blower Relay
6
2
4
3
5
Gas Valve
Lo
C
Hi
Blower Motor


H
Gr.
N
Disconnect
Fuse
2
4
6
Blower Relay
Fan
Switch
Hi
Lo
C
Blower Motor
Upper Limit
Primary
R
C
Secondary
W
Thermostat
G
Limit
Switch
Gas Valve
3
5
Blower Relay Coil

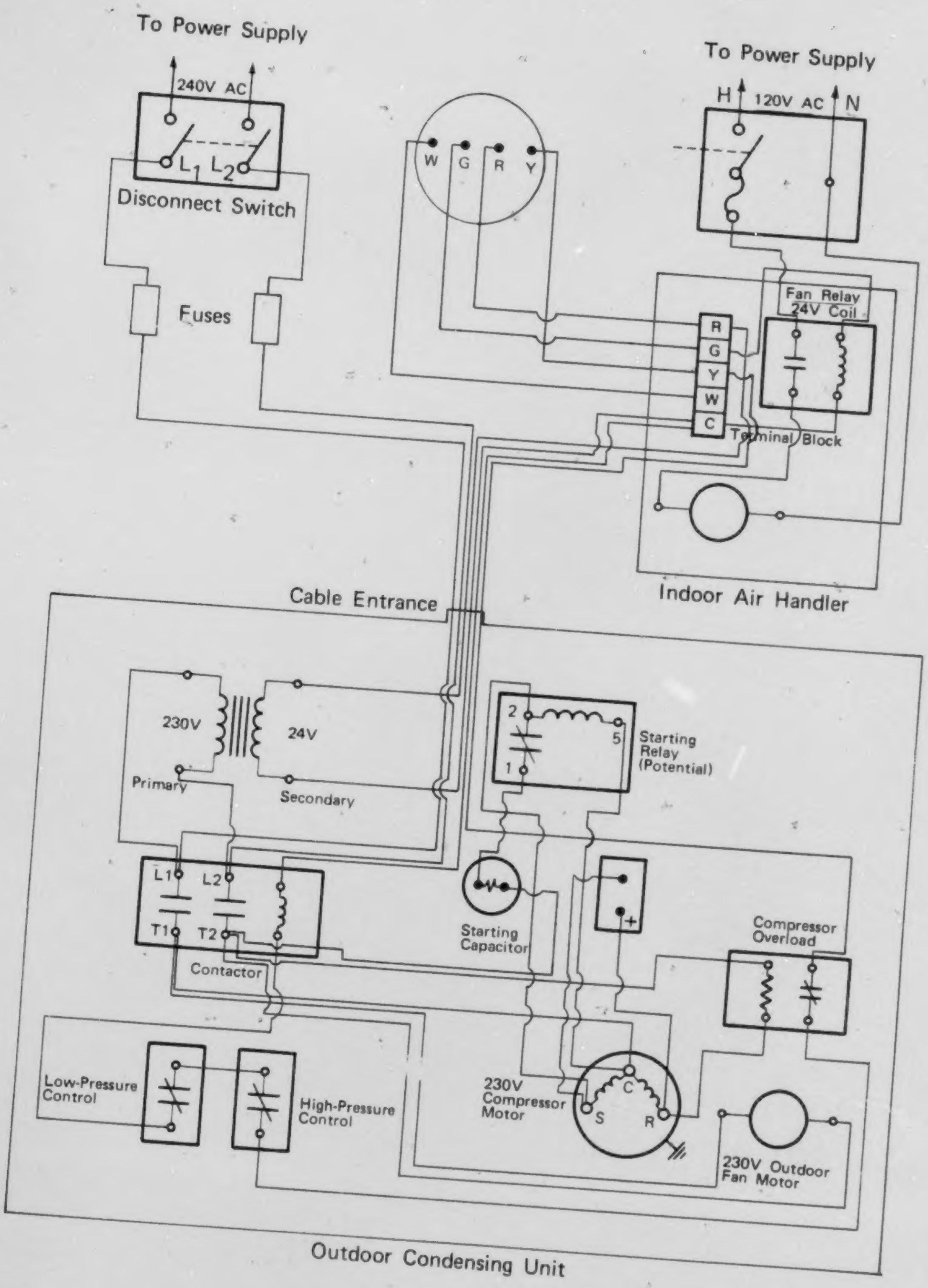
Assignment Sheet #8


Thermostat
R
W1
W2
G
Outdoor Thermostat
Terminal Board
R
Y
G
W2
W1
C
Transformer
C
R
L1
L2
Aux. Cont.
Heater 2
RH2
RH1
Heater 1
Sequencer
Circuit 1
1
2
L1
L2
Fuses
Ground
3
5
4
6
2
Blower Relay
3
4
L1
L2
Circuit 2
Heating Elements
RH1
RH2
RH3
Supp Fan Control
L
H
C
Blower Motor

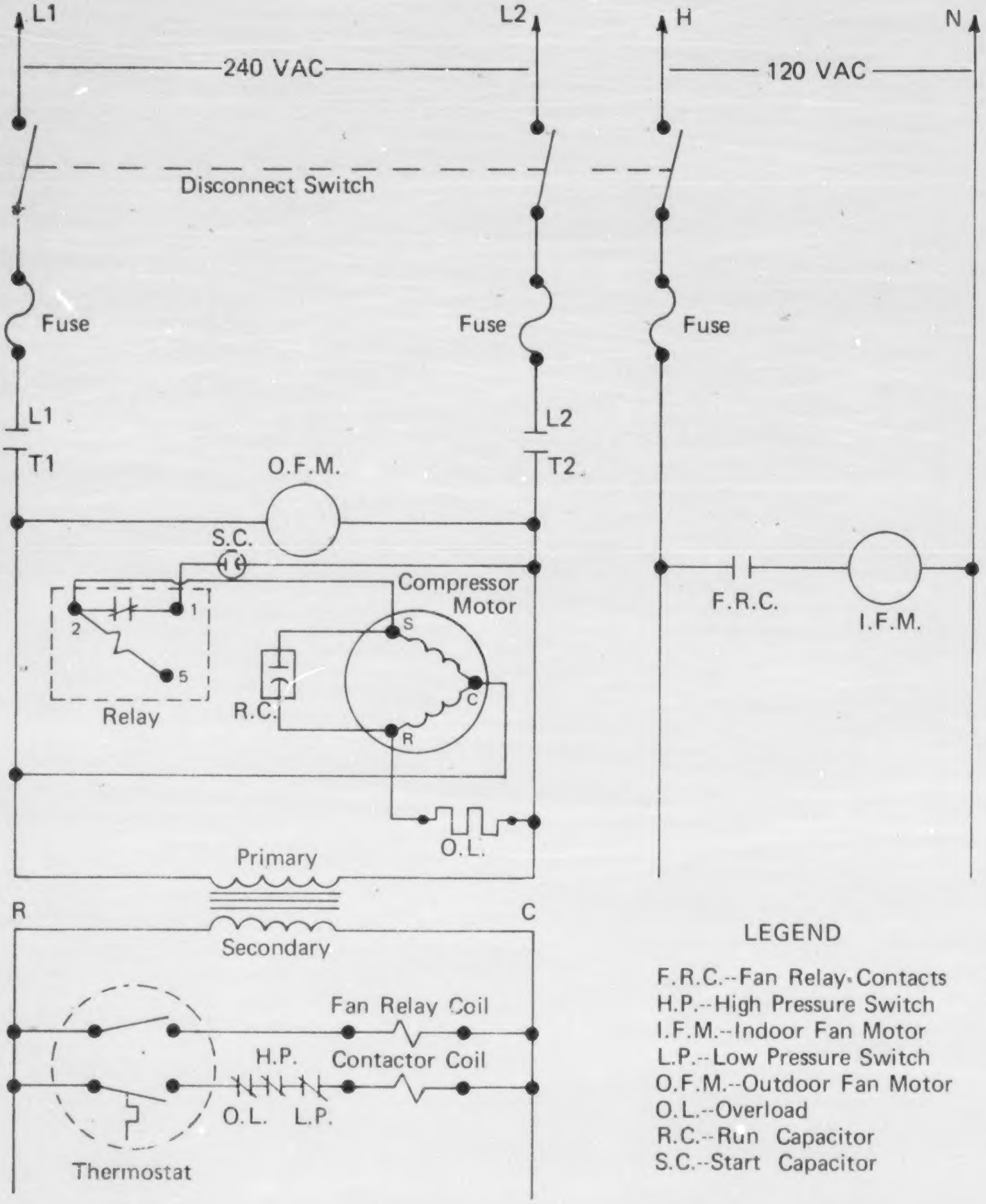
Assignment Sheet #8 (Continued)


L1
L2
L1
L2
Circuit 1
Circuit 2
Fuse 1
Fuse 2
Fuse 3
Fuse 4
2
6
4
S.F.
L
C
H
F.M.
Blower Relay Contacts
RH2
Heating Element 2
Heating Element 1
RH1
Heating Element 3
Auxilary Contacts
Primary
Secondary
W1
W2
G
RH1
RH2
Thermostat
Blower Relay Coil

Assignment Sheet #9


To Power Supply
240V AC
L1 L2
Disconnect Switch
Fuses
W G R Y
To Power Supply
H 120V AC N
Fan Relay 24V Coil
R
G
Y
W
C
Terminal Block
Indoor Air Handler
Cable Entrance
230V
24V
Primary
Secondary
2
5
1
Starting Relay (Potential)
L1 L2
T1 T2
Contactor
Starting Capacitor
+
Compressor Overload
Low-Pressure Control
High-Pressure Control
230V Compressor Motor
C
S
R
230V Outdoor Fan Motor
Outdoor Condensing Unit

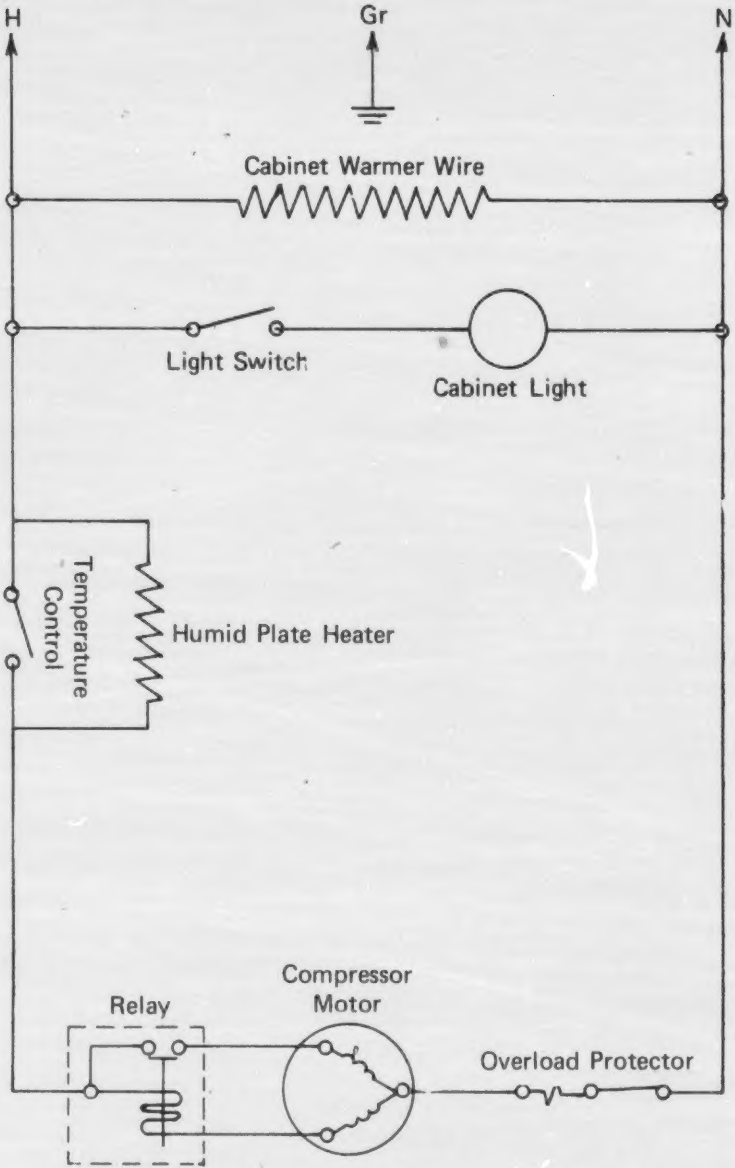
Assignment Sheet #9 (Continued)


L1
L2
H
N
240 VAC
120 VAC
Disconnect Switch
Fuse
Fuse
Fuse
L1
L2
T1
T2
O.F.M.
S.C.
Compressor Motor
S
C
R
2
1
5
Relay
R.C.
O.L.
F.R.C.
I.F.M.
Primary
R
C
Secondary
Fan Relay Coil
H.P.
Contactor Coil
O.L.
L.P.
Thermostat

LEGEND

F.R.C.--Fan Relay Contacts
H.P.--High Pressure Switch
I.F.M.--Indoor Fan Motor
L.P.--Low Pressure Switch
O.F.M.--Outdoor Fan Motor
O.L.--Overload
R.C.--Run Capacitor
S.C.--Start Capacitor

Assignment Sheet #10


H
Gr
N
Cabinet Warmer Wire
Light Switch
Cabinet Light
Temperature Control
Humid Plate Heater
Relay
Compressor Motor
Overload Protector

WIRING DIAGRAMS
UNIT I

JOB SHEET #1–DRAW A LADDER SCHEMATIC BY LOOKING AT A DOMESTIC REFRIGERATOR

I. Tools and materials

A. Domestic refrigerator

B. Standard slot type screwdriver

C. Phillips screwdriver

D. 1/4" nut driver

E. Pencil and paper

II. Procedure

A. Disconnect electrical power to refrigerator

(NOTE: Anytime the electrical power is disconnected from a refrigerator that has been operating the doors should be left open to prevent the formation of mildew and offensive odors.)

B. Check back of refrigerator for a pictorial wiring diagram

C. Remove any panels or grilles necessary to locate electrical components

D. Record make and model number

E. Locate the load of each parallel circuit

F. Locate the controls which are in series with each load

G. Locate mullion and perimeter heater circuits

(NOTE: These heaters are on anytime there is electrical power to the refrigerator, so there will not be a control in series with these loads.)

H. Start a ladder schematic

I. Draw each individual circuit

J. Label all components

K. Have instructor check

L. Replace any panels or grilles that were removed

M. Clean up and put away tools

WIRING DIAGRAMS
UNIT I

JOB SHEET #2--DRAW A LADDER SCHEMATIC BY LOOKING AT A WINDOW AIR-CONDITIONER

I. Tools and materials

- A. Window air conditioner
- B. Standard slot type screwdriver
- C. Phillips screwdriver
- D. 1/4" nut driver
- E. 5/16" nut driver
- F. Pencil and paper

II. Procedure

- A. Disconnect electrical power to the air conditioner
- B. Remove air conditioner from cabinet
- C. Remove any panels necessary to locate electrical components
- D. Record make and model number
- E. Start a ladder schematic
- F. Trace the wiring to the fan motor
- G. Draw the fan motor circuit
- H. Trace the wiring to the compressor
- I. Draw the compressor circuit
- J. Check for any other load circuits
- K. Label all components
- L. Have instructor check
- M. Replace any panels that were removed
- N. Replace air conditioner in its cabinet
- O. Clean up and put away tools

WIRING DIAGRAMS
UNIT I

JOB SHEET #3--DRAW A LADDER SCHEMATIC BY LOOKING AT A SYSTEM WITH LOW VOLTAGE CONTROL

I. Tools and materials

A. Heating or cooling system with 24 VAC control

B. Standard slot type screwdriver

C. Phillips screwdriver

D. 1/4" nut driver

E. 5/16" nut driver

F. Pencil and paper

II. Procedure

A. Disconnect electrical power to system

B. Remove any panels necessary to locate electrical components

C. Record make and model number

D. Locate line voltage loads

E. Locate low voltage loads

F. Start a ladder circuit

G. Show proper fusing

H. Indicate disconnect if used

I. Draw line voltage circuits

J. Draw low voltage circuits

K. Have instructor check

L. Replace any panels that were removed

M. Clean up and put away tools

WIRING DIAGRAMS
UNIT I

NAME______________________________

TEST

1. Match the terms on the right to the correct definitions.

_____a. Line drawing which uses symbols for circuit components

_____b. Descriptive list of the components in a wiring diagram

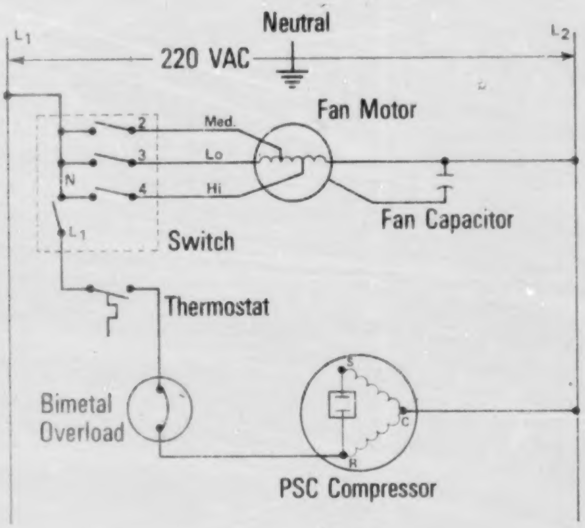
_____c. Wiring diagram which shows either pictures or representative drawings of each component; components are positioned as they would appear in the equipment

_____d. Drawing of electrical circuits

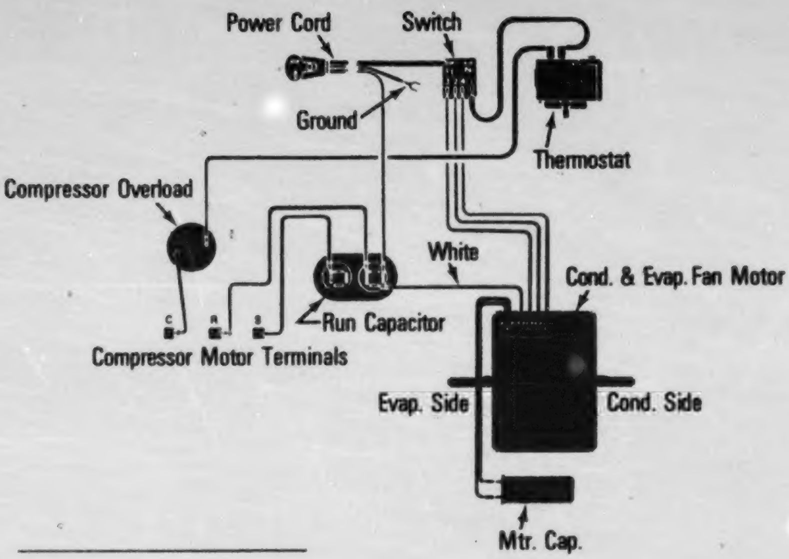
_____e. Drawing which represents a particular component in a wiring diagram

1. Symbol
2. Pictorial
3. Wiring diagram
4. Ladder schematic
5. Legend

2. Identify the wiring diagrams below.


Neutral
L1
220 VAC
L2
Fan Motor
2
Med.
3
Lo
N
4
Hi
L1
Switch
Fan Capacitor
Thermostat
S
Bimetal
Overload
C
R
PSC Compressor

a. ______________________


Power Cord
Switch
Ground
Thermostat
Compressor Overload
White
Cond. & Evap. Fan Motor
C
R
S
Run Capacitor
Compressor Motor Terminals
Evap. Side
Cond. Side
Mtr. Cap.

b. ______________________

3. List seven characteristics of a pictorial wiring diagram.

a.

   1)

   2)

b.

c.

d.

e.

4. List five characteristics of a ladder schematic wiring diagram.

a.

b.

c.

d.

e.

5. List the four major steps in building a ladder schematic.

a.

b.

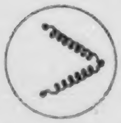
c.

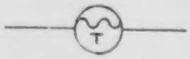
d.

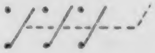
6. Discuss the schematic legend.

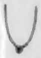
7. Match terms to the correct basic electrical symbols.

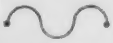
______a. Single pole single throw (SPST)
______b. Ground connection
______c. Capacitor
______d. Push button (normally open)
______e. Switches disconnect
______f. Permanent split capacitor motor
______g. Light
______h. Contacts
______i. Coils
______j. Bimetal switch
______k. Temperature switch
______l. Double pole double throw (DPDT)
______m. Push button (normally closed)
______n. Thermal overload
______o. Fusible link

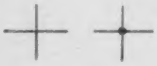
1. 

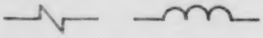
2. 

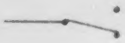
3. 

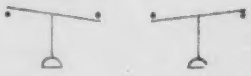
4. 

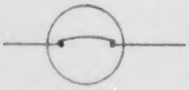
5. 

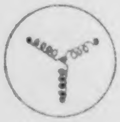
6. 

7. 

8. 

9. 

10. 

11. 

______p. Resistor or resistance heater

______q. Single-phase motor

______r. Single pole double throw (SPDT)

______s. Thermocouple

______t. Thermistor

______u. Three-phase motor

______v. Connectors

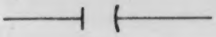
______w. Pressure switches

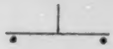
______x. Transformer

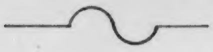
______y. Multiple conductor cable

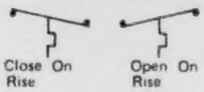
______z. Conductors

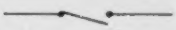
____aa. Fuse

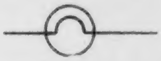
12. 

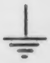
13. 

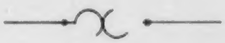
14. 

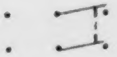
15. 

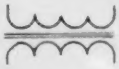
16. 

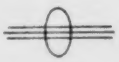
17. 

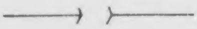
18. 

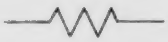
19. 

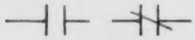
20. 

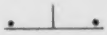
21. 

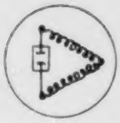
22. 

23. 

24. 

25. 

26. 

27. 

8. Demonstrate the ability to:

   a. Draw a basic schematic wiring diagram.

   b. Draw current relay wiring diagrams.

   c. Draw potential relay wiring diagrams of a self-contained unit.

   d. Draw hot-wire relay wiring diagrams.

   e. Draw gas furnace wiring diagrams.

   f. Draw outdoor condensing unit wiring diagrams.

   g. Draw gas furnace wiring diagrams with two limit switches.

   h. Draw electric furnace wiring diagrams.

   i. Draw indoor air handler and outdoor condensing unit wiring diagram.

   j. Draw a domestic refrigerator wiring diagram.

   k. Draw a ladder schematic by looking at a domestic refrigerator.

   l. Draw a ladder schematic by looking at a window air conditioner.

   m. Draw a ladder schematic by looking at a system with low voltage control circuit.

   (NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

WIRING DIAGRAMS
UNIT I

ANSWERS TO TEST

1. a. 4
   b. 5
   c. 2
   d. 3
   e. 1

2. a. Ladder schematic
   b. Pictorial

3. a. System components
      1) Representative drawings
      2) Detailed reproductions
   b. Shows components in their approximate location
   c. Provides a good guide for field wiring
   d. Circuits are difficult to trace
   e. Line voltage and low voltage circuits are shown together

4. a. System components are shown by symbols
   b. Schematic wiring diagrams build a ladder
   c. Ladder rungs are individual circuits
   d. Line voltage and low voltage are separated
   e. Circuit troubleshooting is easy

5. a. Establish power source
   b. Identify loads
   c. Identify control switches for each circuit
   d. Connect all circuits across the line

6. Discussion should include:
   - a. Identifies schematic components
   - b. Distinguishes differences in manufacturer's symbols
   - c. Aids in locating components

7.

a.	16	h.	25	o.	5	v.	23
b.	18	i.	7	p.	24	w.	9
c.	12	j.	10	q.	1	x.	21
d.	13	k.	15	r.	8	y.	22
e.	3	l.	20	s.	4	z.	6
f.	27	m.	26	t.	2	aa.	14
g.	17	n.	19	u.	11		

8. Performance skills evaluated to the satisfaction of the instructor

DOMESTIC REFRIGERATION FUNDAMENTALS
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to match terms associated with domestic refrigeration and identify types of domestic refrigeration, refrigerator cabinet hardware, and trim. The student should also be able to list data plate information, locations of data plates, reasons for transporting the refrigerator upright, and the six most common refrigerator problems. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with domestic refrigeration to the correct definitions.
2. Identify types of domestic refrigeration.
3. Identify refrigerator cabinet hardware and trim.
4. List eight items of information given on a refrigerator data plate.
5. List three common locations of refrigerator data plates.
6. List two major reasons why a refrigerator should be transported upright.
7. List the six most common domestic refrigerator problems.
8. Demonstrate the ability to:
    a. Install a refrigerator.
    b. Remove and replace breaker trim.
    c. Adjust a door.

DOMESTIC REFRIGERATION FUNDAMENTALS
UNIT I

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate and discuss the procedures outlined in the job sheets.

   G. Have students disassemble and reassemble a refrigerator.

   H. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Complete job sheets.

   D. Practice removing and replacing breaker trim.

   E. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM 1--Domestic Refrigeration

      2. TM 2--Cabinet Hardware and Trim

- D. Job sheets
    1. Job Sheet #1--Install a Refrigerator
    2. Job Sheet #2--Remove and Replace Breaker Trim
    3. Job Sheet #3--Adjust a Door
- E. Test
- F. Answers to test

II. References:

A. Althouse, Andrew D.; Turnquist, Carl H.; and Bracciano, Alfred F. *Modern Refrigeration and Air Conditioning.* Homewood, Illinois: Goodheart-Willcox Company, Inc., 1975.

B. *Refrigeration, Part II.* Benton Harbor, Michigan: Whirlpool Corp., 1974.

DOMESTIC REFRIGERATION FUNDAMENTALS
UNIT I

INFORMATION SHEET

I. Terms and definitions

   A. Domestic refrigeration--Refrigerated appliance which is used within the home

   B. Breaker strip--Plastic trim that covers the space between the cabinet and the liner of the refrigerator

   C. Mullion--Divider between two refrigerated sections

   D. Baffle--Plate or vane to control or direct the air within a confined area

   E. Damper--Valve for controlling air flow

   F. Gasket--Resilient or flexible material used around refrigerator doors to provide a leak-proof seal

   G. Urethane foam--Insulation which is foamed in between the inner and outer walls of the refrigerator

      (NOTE: Other types of insulation are also used in refrigerators.)

   H. Data plate--Tag on the refrigerator which gives the vital electrical and refrigerant charge information

   I. Crisper--Compartment in a refrigerator which provides high humidity and cool temperature for keeping fresh leafy vegetables cool and crisp

II. Domestic refrigeration (Transparency 1)

   A. Refrigerators

   B. Side-by-side refrigerator-freezers

   C. Chest freezers

   D. Upright freezers

III. Cabinet hardware and trim (Transparency 2)

   A. Door handle

   B. Door gasket

   C. Door liner

INFORMATION SHEET

- D. Butter keeper
- E. Breaker strip
- F. Mullion strip
- G. Inner liner
- H. Toe plate
- I. Outer liner
- J. Crisper

IV. Data plate information

- A. Brand name
- B. Model number
- C. Serial number
- D. Voltage
- E. Full load amperage

  (NOTE: Some models of refrigerators do not give the running amperage.)

- F. Locked rotor amperage
- G. Type of refrigerant
- H. Amount of refrigerant

V. Common locations of data plates

- A. Back of cabinet
- B. Lower front of cabinet

  (NOTE: The toe plate will need to be removed on some models to see the data plate.)

- C. Lower left inside of cabinet liner

  (NOTE: This would be from standing in front of the refrigerator looking into it and the left hand crisper may have to be removed in order to read the data plate.)

INFORMATION SHEET

VI. Reasons for transporting a refrigerator upright

A. To keep oil in compressor

(NOTE: If the refrigerator is laid down the oil may leave the compressor and go into the refrigerant lines or compression cylinders which may cause oil restrictions or compressor seizure.)

B. To prevent damage to motor windings

(NOTE: The compressor is spring mounted inside the dome and laying the refrigerator on its side may cause the compressor windings to hit the side of the dome which could cause a damaged winding.)

VII. Common refrigerator problems

A. Improper installation

B. Doors out of adjustment or poor cabinet seal

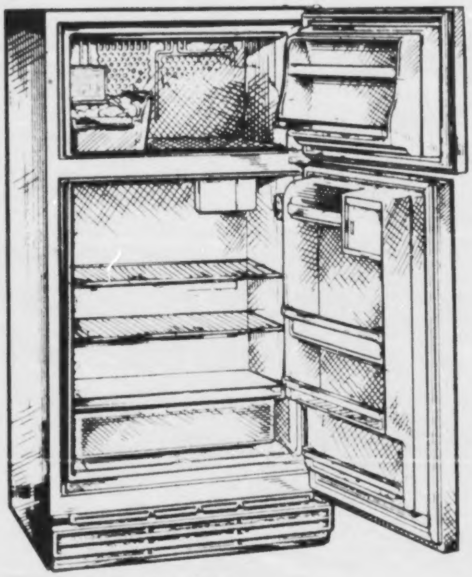
C. Improper or no air circulation

D. Improper defrosting

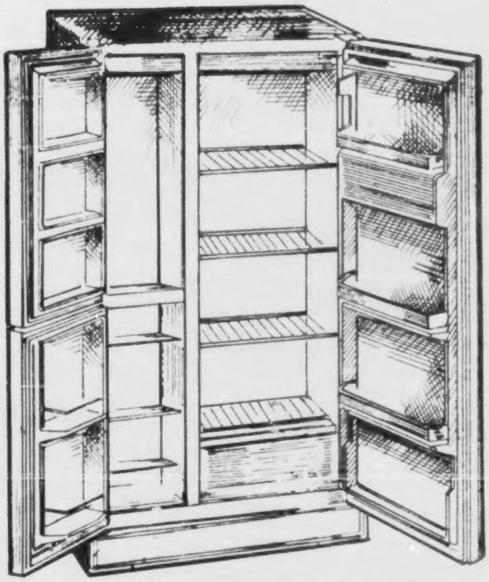
E. Defrost water disposal problems

F. Malfunctioning electrical components

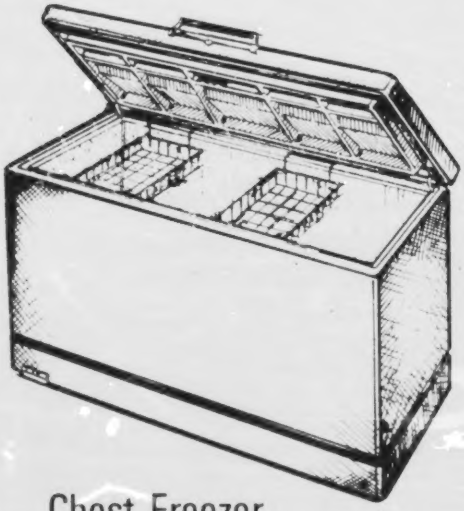
Domestic Refrigeration



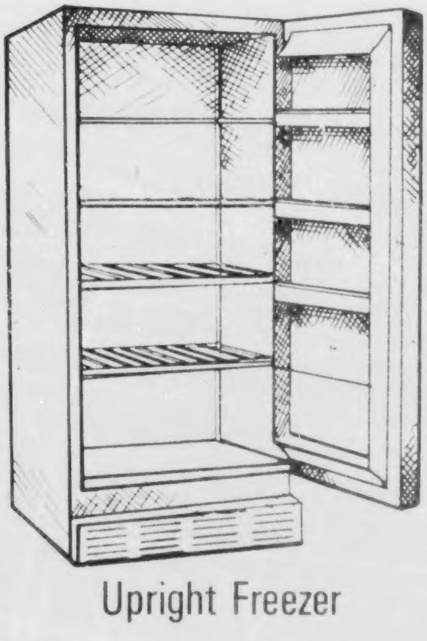
Refrigerator



Side-By-Side
Refrigerator-Freezer

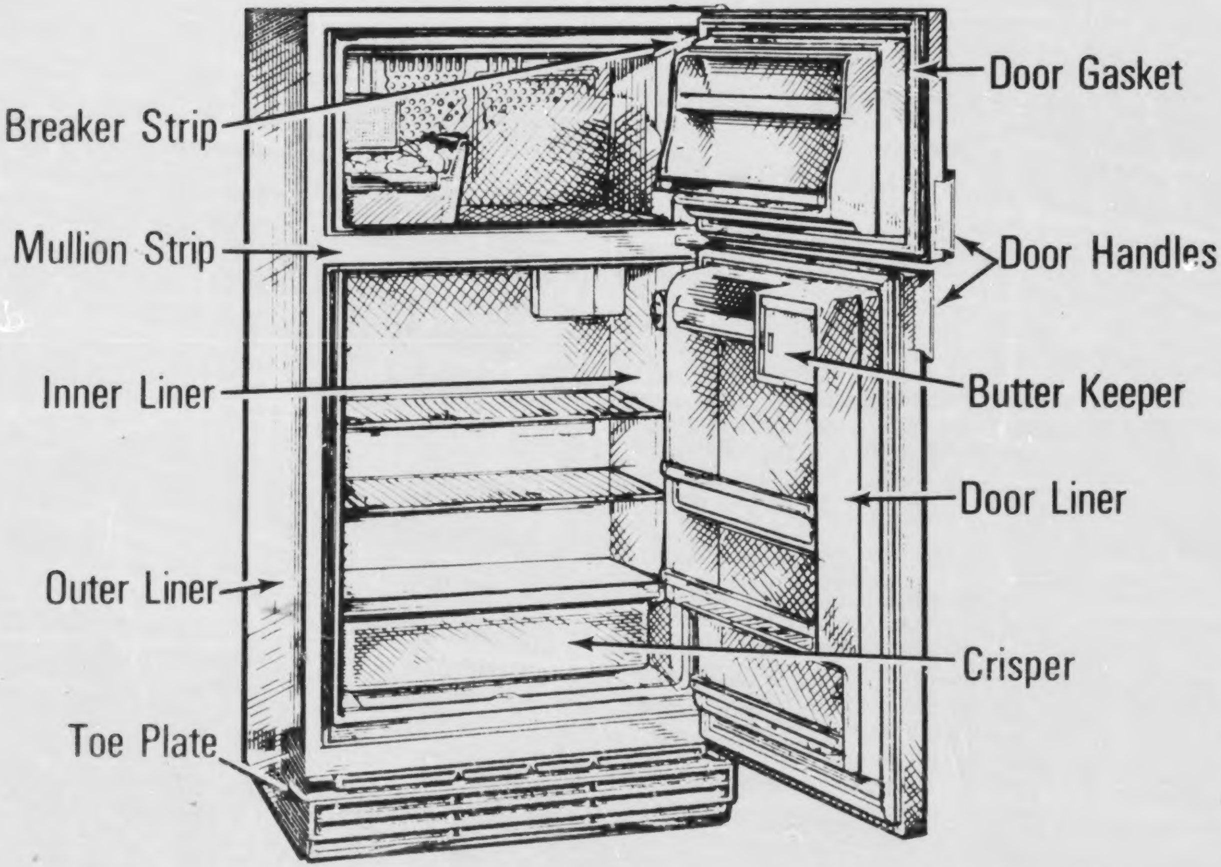


Chest Freezer



Upright Freezer

Cabinet Hardware and Trim


Breaker Strip
Mullion Strip
Inner Liner
Outer Liner
Toe Plate
Door Gasket
Door Handles
Butter Keeper
Door Liner
Crisper

DOMESTIC REFRIGERATION FUNDAMENTALS
UNIT I

JOB SHEET #1--INSTALL A REFRIGERATOR

I. Tools and materials

- A. Refrigerator
- B. Adjustable open end wrench

II. Procedure

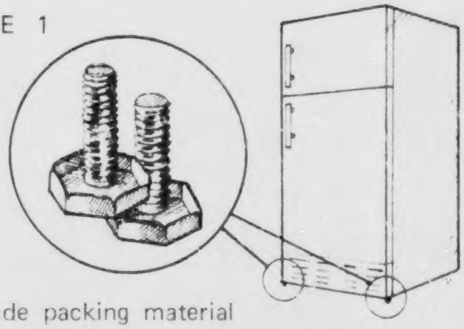
- A. Locate the refrigerator in the proper place

  (NOTE: The refrigerator should not be located in the direct sunlight or close to a heat source.)

- B. Allow a half inch clearance on each side of the refrigerator
- C. Allow one inch clearance behind for models with a static condenser
- D. Allow three inch clearance above for proper air circulation
- E. Remove toe plate
- F. Adjust leveling legs and check (Figure 1)

  (NOTE: On most models the leveling legs are located on the front only, but may be installed on the rear if necessary.)

FIGURE 1



- G. Remove inside packing material
- H. Clean outside and inside of refrigerator

  (NOTE: The cleaning solvent being used should be designed for this purpose and not damage the finish or leave odors inside the refrigerator.)

- I. Check doors for proper closing
- J. Have instructor check
- K. Clean up and put away tools and materials

DOMESTIC REFRIGERATION FUNDAMENTALS
UNIT I

JOB SHEET #2--REMOVE AND REPLACE BREAKER TRIM

I. Tools and materials

A. Wood block, 6" x 4" x 1"

B. Standard slot type screwdriver

C. Phillips screwdriver

D. Refrigerator

II. Procedure

A. Disconnect refrigerator from electrical power

B. Open refrigerator doors

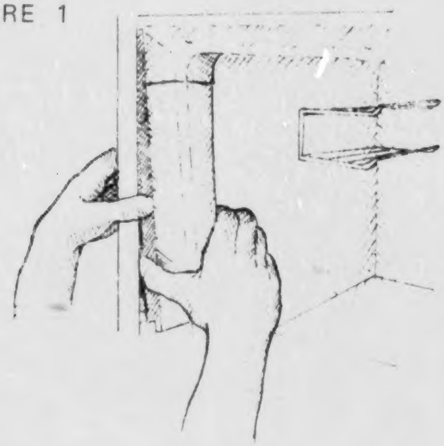
C. Allow inside of refrigerator to warm to room temperature

(NOTE: If in a hurry soak a towel in hot water, ring it out, and place it on the breaker to warm the breaker trim.)

D. Remove side breakers first

E. Start at bottom front edge of side breaker (Figure 1)

FIGURE 1



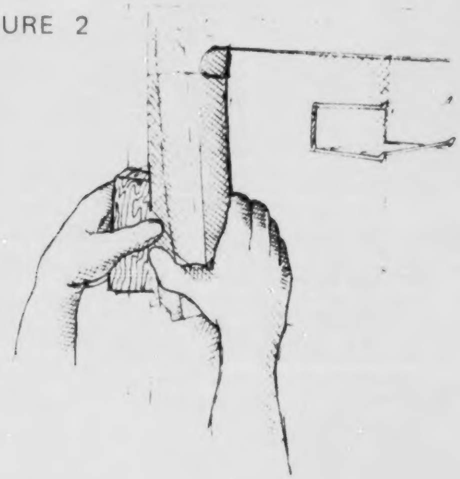
JOB SHEET #2

F. Do not use screwdriver to pry the trim

(NOTE: Using a screwdriver may damage the finish on the refrigerator and break the trim.)

G. Use the wood block to get the trim loose if it is stuck (Figure 2)

FIGURE 2

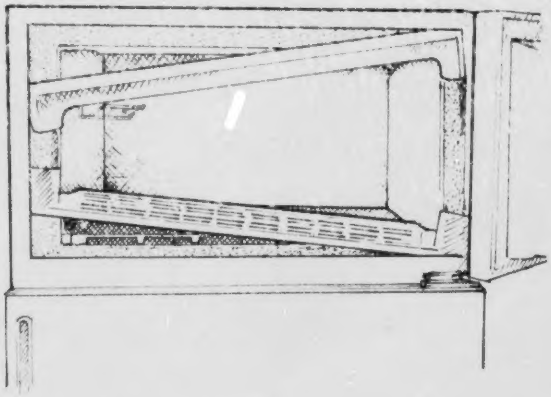


H. Pull trim forward to disengage it from the liner

(NOTE: Do not damage light switch or wires when removing side trim.)

I. Pull down and forward on one end of top trim (Figure 3)

FIGURE 3



J. Complete removal of top trim

K. Pull up and forward on one end of bottom trim

JOB SHEET #2

L. Complete removal of bottom trim

M. Check insulation for wetness

(NOTE: If the insulation is wet remove it and dry it or replace it.)

N. Have instructor check

O. Replace bottom trim by inserting one end first

P. Push down and back on trim

(NOTE: Trim may have to be twisted slightly to get the back to slip under the liner.)

Q. Replace top trim by inserting one end first

R. Push up and back on trim

S. Replace side trims

T. Insert top and back of trim first

U. Push back on trim and insert front of trim behind cabinet flange clips

V. Clean finger prints from trim and cabinet

W. Have instructor check

X. Clean up and put away tools and materials

DOMESTIC REFRIGERATION FUNDAMENTALS
UNIT I

JOB SHEET #3--ADJUST A DOOR

I. Tools and materials

   A. Refrigerator

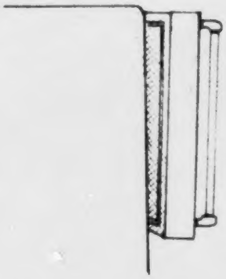
   B. Phillips screwdriver

   C. Nutdriver

II. Procedure

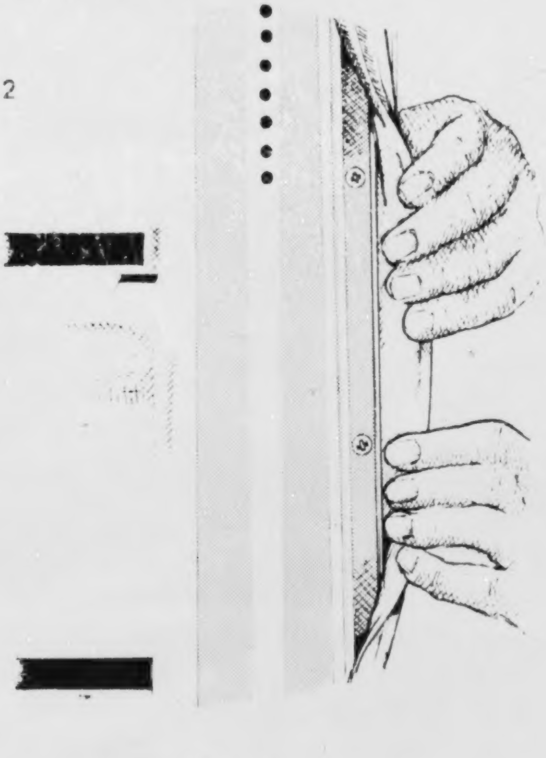
   A. Check for gap between door gaskets and cabinet front (Figure 1)

FIGURE 1



   B. Loosen gasket retainer screws (Figure 2)

FIGURE 2



JOB SHEET #3

C. Twist door in opposite direction (Figure 3)

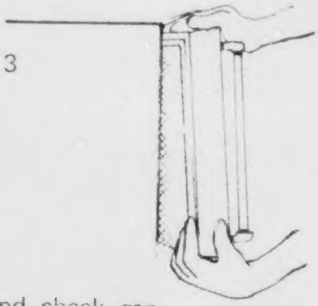


FIGURE 3

D. Close door and check gap

E. Retighten screws until snug

(NOTE: Do not overtighten the screws because this may cause the door to twist out of alignment.)

F. Have instructor check

G. Clean up and put away tools and materials

DOMESTIC REFRIGERATION FUNDAMENTALS
UNIT I

NAME ______________________.

TEST

1. Match the terms on the right to the correct definitions.

_____a. Valve for controlling air flow

_____b. Resilient or flexible material used around refrigerator doors to provide a leak-proof seal

_____c. Divider between two refrigerated sections

_____d. Tag on the refrigerator which gives the vital electrical and refrigerant charge information

_____e. Plastic trim that covers the space between the cabinet and the liner of the refrigerator

_____f. Insulation which is foamed in between the inner and outer walls of the refrigerator

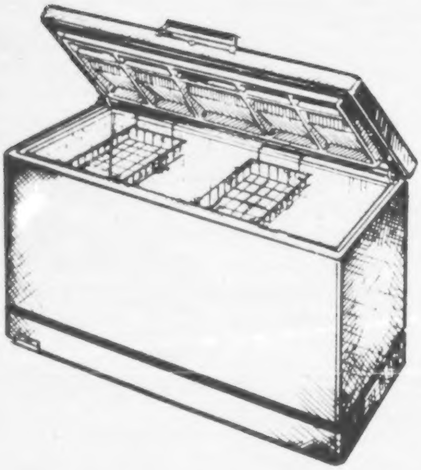
_____g. Compartment in a refrigerator which provides high humidity and cool temperature for keeping fresh leafy vegetables cool and crisp

_____h. Plate or vane to control or direct the air within a confined area

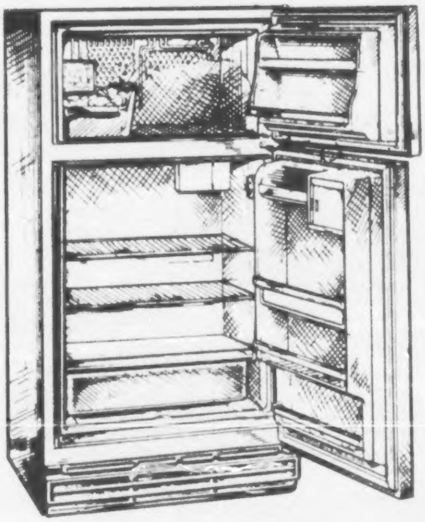
_____i. Refrigerated appliance which is used within the home

1. Data plate
2. Damper
3. Urethane foam
4. Mullion
5. Breaker strip
6. Domestic refrigeration
7. Crisper
8. Gasket
9. Baffle

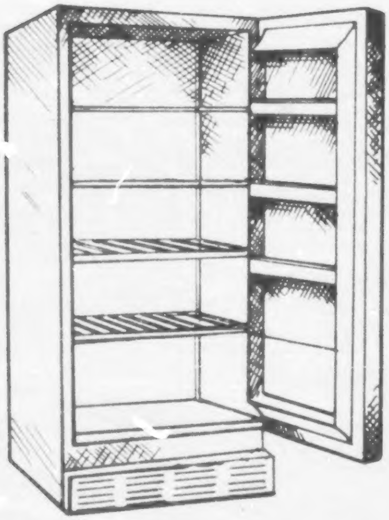
2. Identify types of domestic refrigeration.



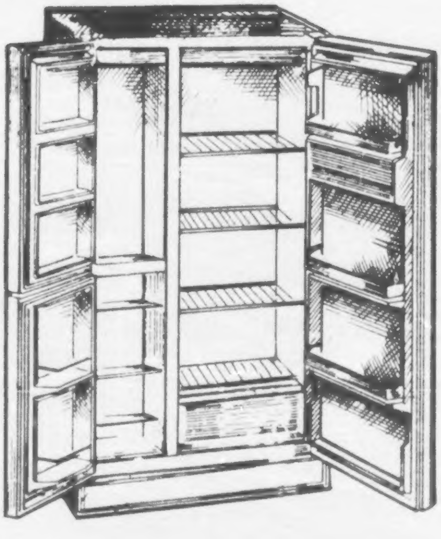
a. ______________________



b. ______________________

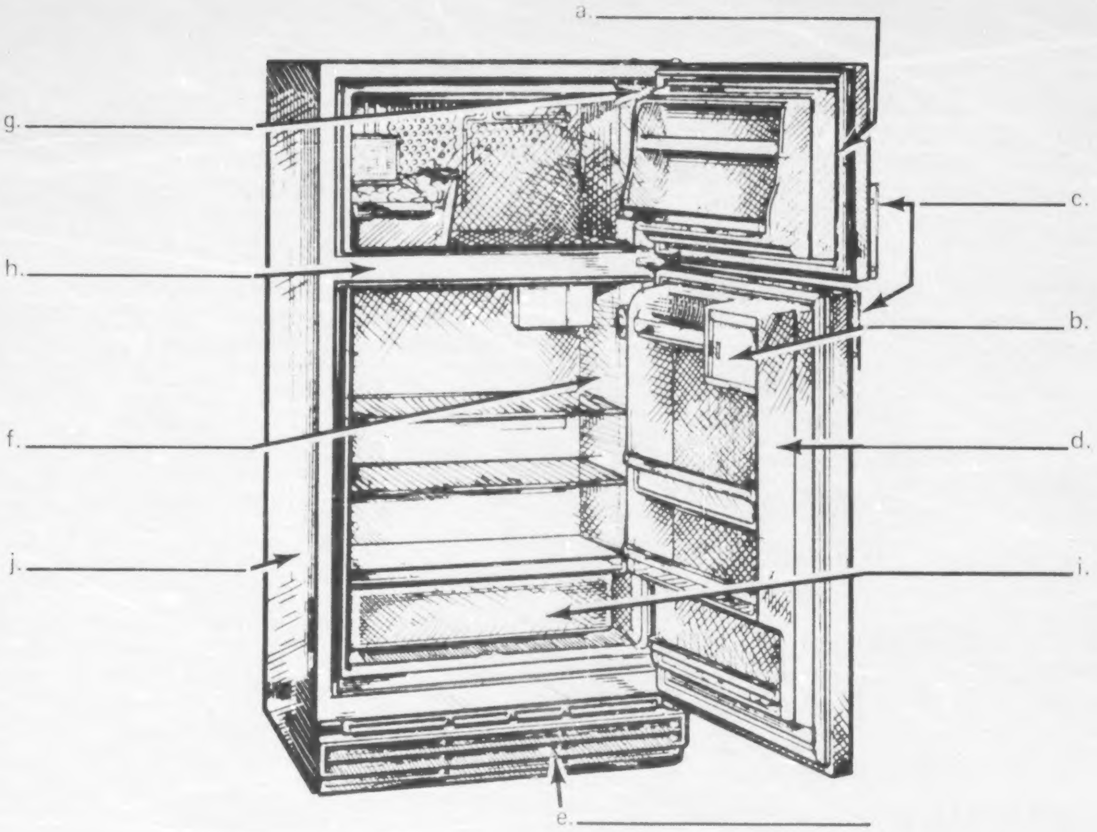


c. ______________________



d. ______________________

3. Identify refrigerator cabinet hardware and trim.



4. List eight items of information given on a refrigerator data plate.

a.

b.

c.

d.

e.

f.

g.

h.

5. List three common locations of refrigerator data plates.

   a.

   b.

   c.

6. List two major reasons why a refrigerator should be transported upright.

   a.

   b.

7. List the six most common domestic refrigerator problems.

   a.

   b.

   c.

   d.

   e.

   f.

8. Demonstrate the ability to:

   a. Install a refrigerator.

   b. Remove and replace breaker trim.

   c. Adjust a door.

   (NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

DOMESTIC REFRIGERATION FUNDAMENTALS
UNIT I

ANSWERS TO TEST

1. a. 2
   b. 8
   c. 4
   d. 1
   e. 5
   f. 3
   g. 7
   h. 9
   i. 6

2. a. Chest freezer
   b. Refrigerator
   c. Upright freezer
   d. Side-by-side refrigerator-freezer

3. a. Door gasket
   b. Butter keeper
   c. Door handles
   d. Door liner
   e. Toe plate
   f. Inner liner
   g. Breaker strip
   h. Mullion strip
   i. Crisper
   j. Outer liner

4. a. Brand name
   b. Model number
   c. Serial number
   d. Voltage
   e. Full load amperage

f. Locked rotor amperage

g. Type of refrigerant

h. Amount of refrigerant

5. a. Back of cabinet

b. Lower front of cabinet

c. Lower left inside of cabinet liner

6. a. To keep oil in compressor

b. To prevent damage to motor windings

7. a. Improper installation

b. Doors out of adjustment or poor cabinet seal

c. Improper or no air circulation

d. Improper defrosting

e. Defrost water disposal problems

f. Malfunctioning electrical components

8. Performance skills evaluated to the satisfaction of the instructor

SEALED SYSTEM COMPONENTS
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to define terms associated with sealed system components, list and discuss various components, and identify the types of components. The student should also be able to replace or install components. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Define terms associated with sealed system components.
2. List the eleven sealed system components of a domestic refrigerator.
3. Discuss the functions of the sealed system components in a domestic refrigerator.
4. Identify types of evaporators.
5. List the five locations of evaporators.
6. Identify types of compressors.
7. Identify types of condensers.
8. List the three locations of condensers.
9. List the six items of information needed when replacing a capillary tube.
10. Demonstrate the ability to:
    a. Replace a compressor.
    b. Install a low side service stub on a reciprocal compressor.
    c. Install service stubs in refrigerant lines.
    d. Replace a capillary tube.
    e. Install a liquid line filter-drier.

SEALED SYSTEM COMPONENTS
UNIT II

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate and discuss the procedures outlined in the job sheets.

   G. Review silver brazing procedures.

   H. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Complete job sheets.

   D. Replace various types of domestic compressors.

   E. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM 1--Evaporators

      2. TM 2--Evaporator Location

3. TM 3--Compressors

4. TM 4--Condensers

5. TM 5--Condensers (Continued)

D. Job sheets

1. Job Sheet #1--Replace a Compressor

2. Job Sheet #2--Install a Low Side Service Stub on a Reciprocal Compressor

3. Job Sheet #3--Install Service Stubs in Refrigerant Lines

4. Job Sheet #4--Replace a Capillary Tube

5. Job Sheet #5--Install a Liquid Line Filter-Drier

E. Test

F. Answers to test

II. References:

A. Althouse, Andrew D.; Turnquist, Carl H.; and Bracciano, Alfred F. *Modern Refrigeration and Air Conditioning.* Homewood, Illinois: Goodheart-Willcox Company, Inc., 1975.

B. *Refrigeration Service, Part I.* Benton Harbor, Michigan: Whirlpool Corp., 1974.

SEALED SYSTEM COMPONENTS
UNIT II

INFORMATION SHEET

I. Terms and definitions

   A. In-wall condenser--Condenser tubing is attached to the inside walls of the outer liner of the refrigerator or freezer cabinet

   B. Plate condenser--Condenser tubing is attached to a sheet metal plate and can be either forced air or static

   C. In-wall evaporator--Evaporator tubing is attached to the outside walls of the inner liner and is used primarily on freezers

   D. Cold plate--Evaporator tubing is attached to a plate

      (NOTE: This type of evaporator is often used in refrigerators that do not have forced air evaporators.)

II. Sealed system components of a domestic refrigerator

   A. Compressor

   B. Evaporator

   C. Condenser

   D. Capillary tube

   E. Discharge line

   F. Liquid line

   G. Suction line

   H. Liquid line filter-drier

   I. Accumulator

   J. Oil cooler

   K. Precooler

III. Functions of sealed system components of a domestic refrigerator

   A. Compressor

      1. Lowers pressure in evaporator

      2. Compresses heat laden refrigerant vapor

INFORMATION SHEET

B. Evaporator–Transfers heat

C. Condenser–Dissipates the heat from the refrigerant

D. Capillary tube

    1. Meters refrigerant into evaporator

    2. Provides a point of expansion

E. Discharge line–Carries the refrigerant from the compressor to the inlet of the condenser

F. Liquid line–Carries the refrigerant from the outlet of the condenser to the inlet of the metering device

G. Suction line–Carries the refrigerant from the outlet of the evaporator to the compressor

H. Liquid line filter-drier

    1. Adsorbs or absorbs moisture from refrigerant

    2. Filters contaminants from refrigerant

I. Accumulator–Prevents liquid refrigerant from entering the compressor

J. Oil cooler–Absorbs heat from compressor oil

IV. Evaporators (Transparency 1)

A. Static

    1. Shell

    2. Shelf

    3. Cold plate

B. Forced air–Fin

V. Locations of evaporators (Transparency 2)

A. Entire freezer compartment

B. Back wall of food compartment (cold plate)

C. Back wall of freezer compartment

D. Bottom of freezer compartment

E. Shelves of upright freezer

INFORMATION SHEET

VI. Types of compressors (Transparency 3)

A. Reciprocal

B. Rotary

VII. Types of condensers (Transparencies 4 and 5)

A. Static

1. Fin

2. Plate

3. Tube (in-wall)

B. Forced air

1. Fin

2. Plate

3. Tube

VIII. Locations of condensers

A. In-wall

B. Back of refrigerator

C. Underneath refrigerator

IX. Information needed when replacing a capillary tube

A. Inside diameter of original capillary tube

B. Length of original capillary tube

C. Horsepower of compressor motor

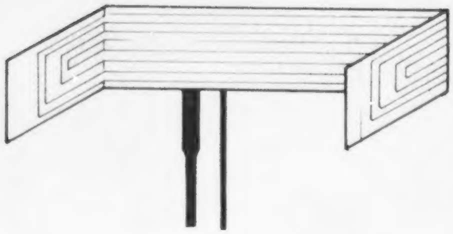
D. Temperature range of system

E. Type of refrigerant

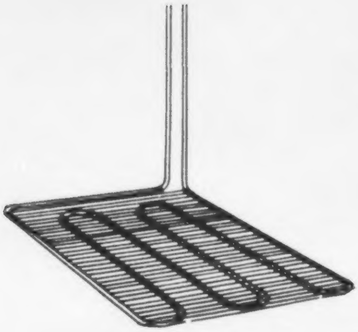
F. Type of condenser

Evaporators

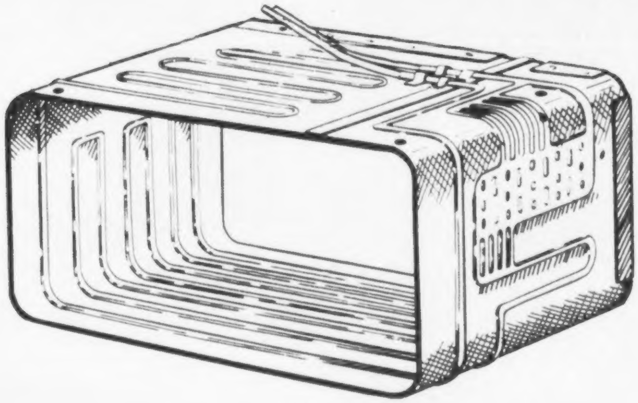
Static



Cold Plate

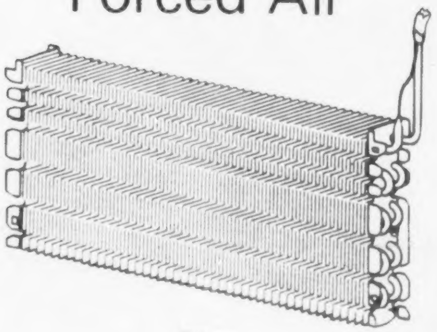


Shelf



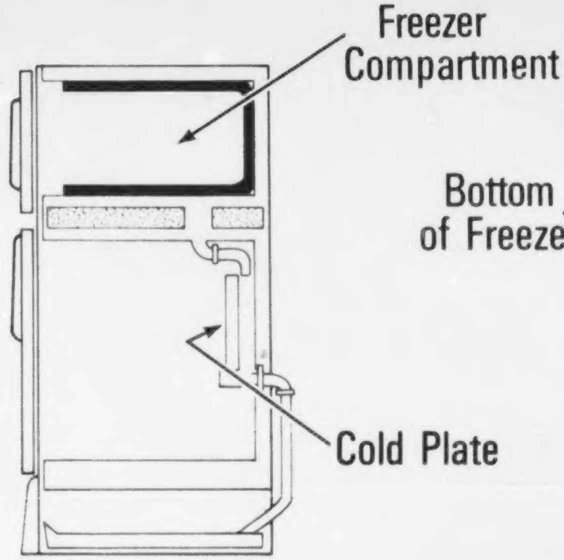
Shell

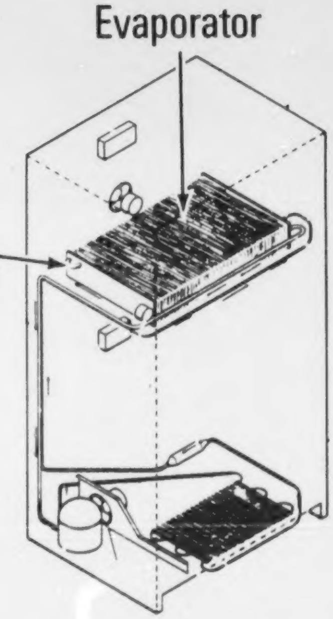
Forced Air

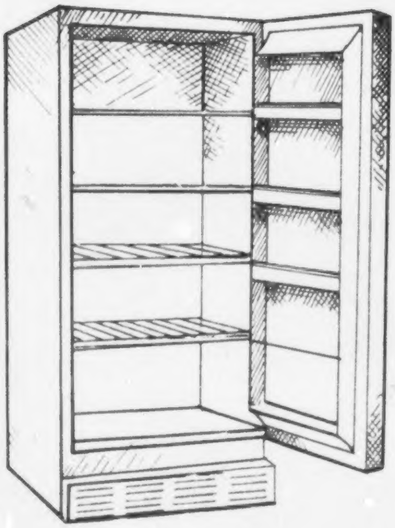


Fin

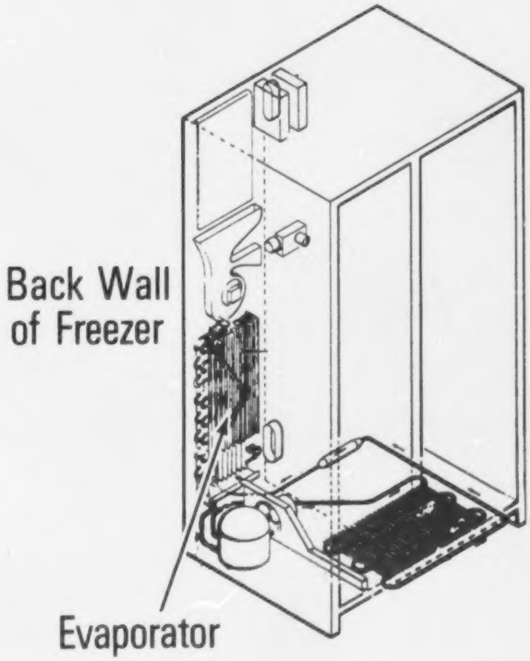
Evaporator Location


Freezer Compartment
Cold Plate


Evaporator
Bottom of Freezer

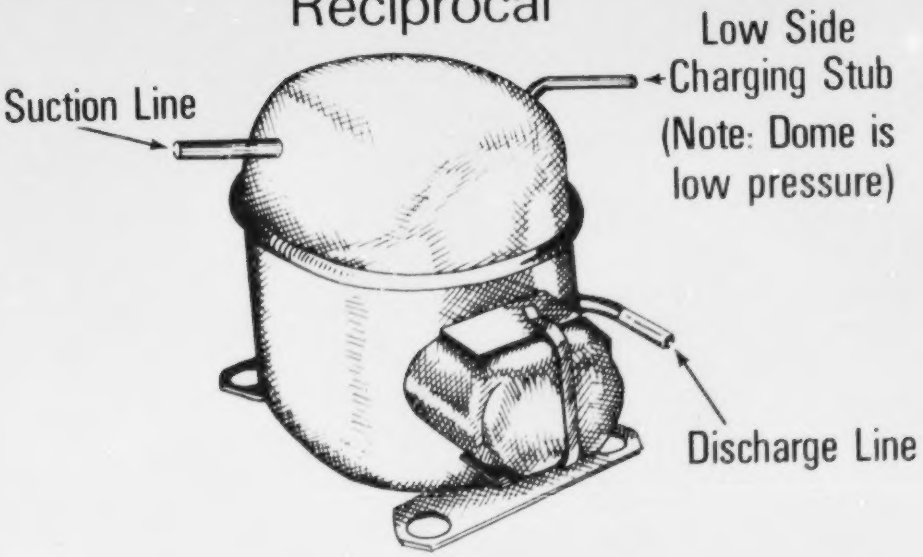


Freezer Shelves

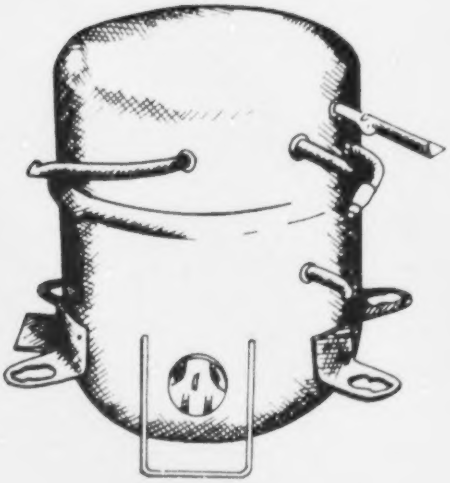

Back Wall of Freezer
Evaporator

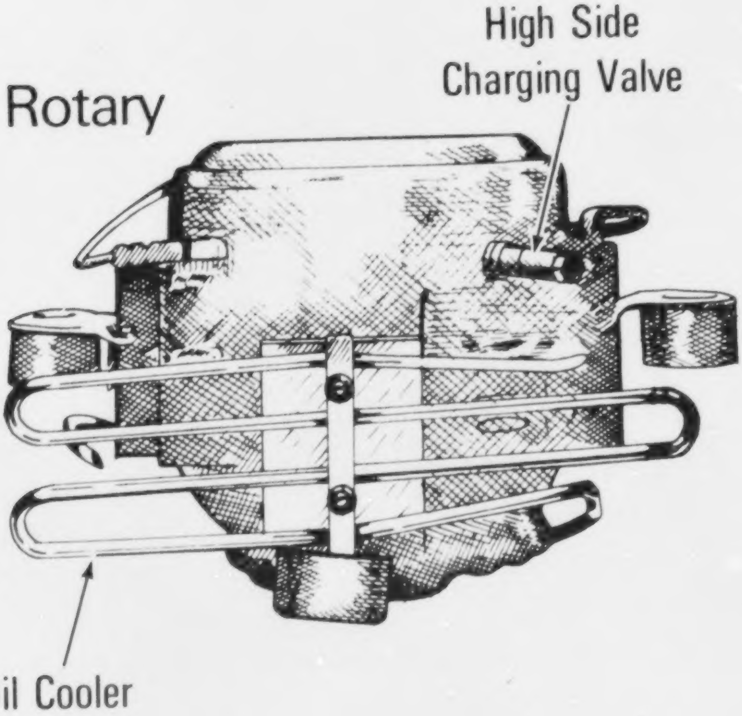
Compressors

Reciprocal


Suction Line
Low Side
Charging Stub
(Note: Dome is
low pressure)
Discharge Line

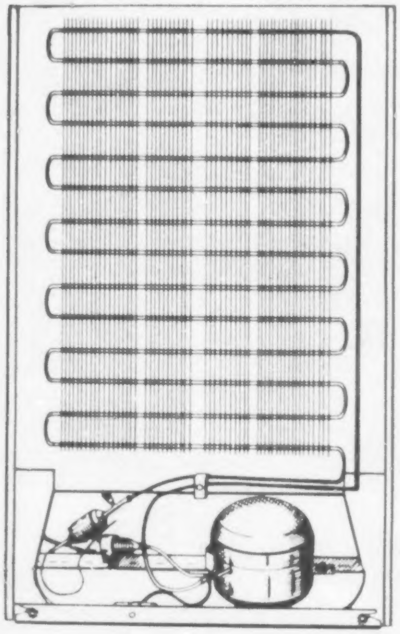
Rotary



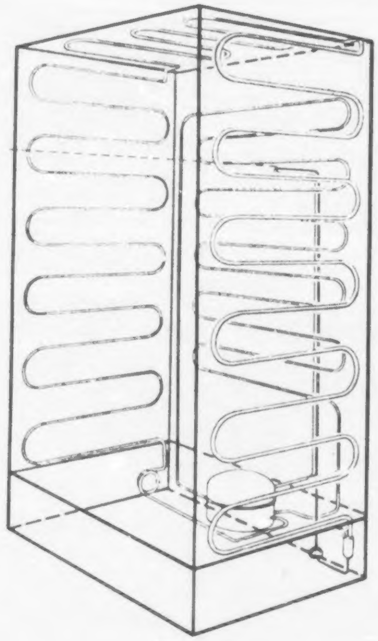

High Side
Charging Valve
Oil Cooler

Condensers

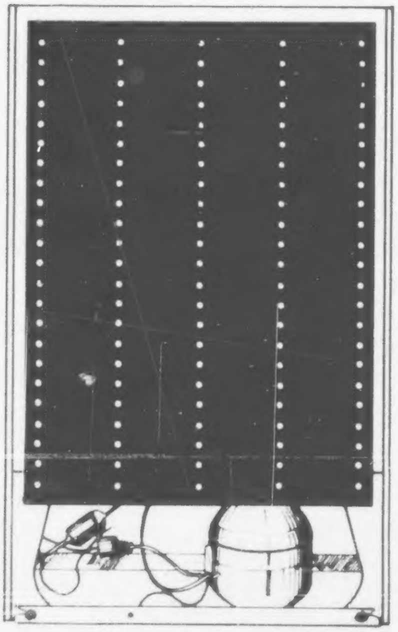
Static



Fin



Tube
(In-Wall)

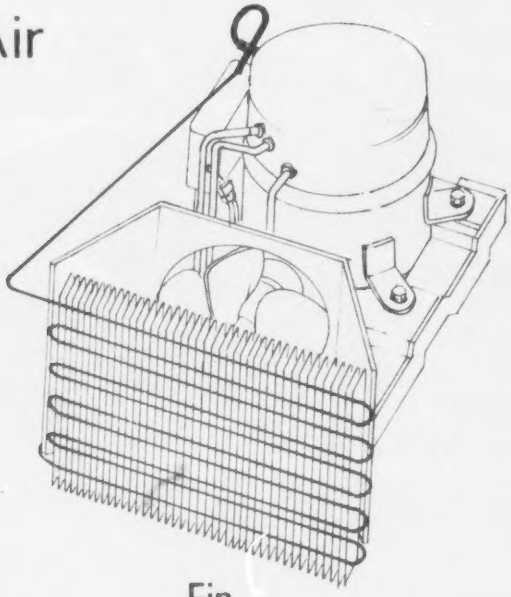


Plate

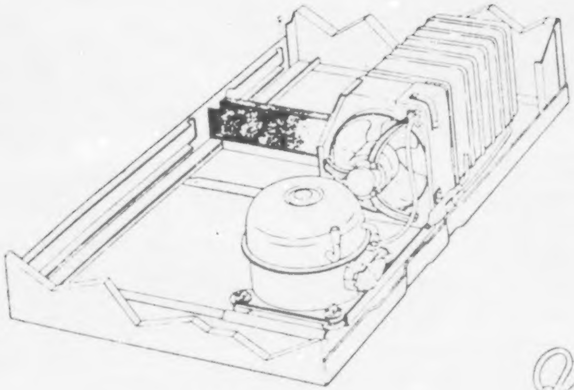
Condensers

(Continued)

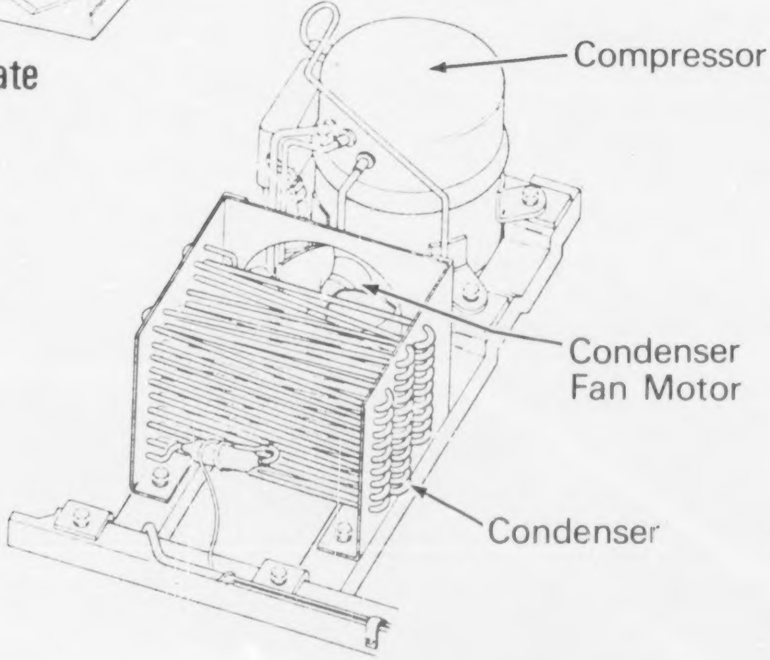
Forced Air



Fin



Plate


Compressor
Condenser Fan Motor
Condenser

Tube

SEALED SYSTEM COMPONENTS
UNIT II

JOB SHEET #1-REPLACE A COMPRESSOR

I. Tools and materials

   A. Tubing cutter

   B. Combination open end-box end wrench

   C. Side cutters

   D. Domestic refrigeration system

   E. Two shop towels

   F. Safety glasses

   G. Sand cloth

   H. Torch

   I. Striker

   J. Silver brazing alloy

   K. Silver solder flux

II. Procedure

   A. Check to see that the refrigerator is disconnected from electrical power

   B. Put on safety glasses

   C. Discharge refrigerant slowly

   (CAUTION: Be sure and have proper ventilation when discharging refrigerant.)

   (NOTE: If system does not have a service valve, cut the end of a service stub with the side cutters.)

   D. Place shop towel around valve to catch oil

   E. Allow entire refrigerant charge to escape before proceeding

   F. Remove electrical components from compressor

   G. Polish tubing at the spot it is to be cut

   H. Cut tubing from compressor with tubing cutter

   I. Remove compressor hold down bolts

JOB SHEET #1

J. Lift compressor out

K. Polish cut ends of tubing

L. Set new compressor in place

M. Replace hold down bolts and tighten

N. Remove plugs from compressor lines

(CAUTION: There will be pressure on the compressor.)

O. Coat polished ends of tubing with a small amount of flux

P. Insert tubing into compressor

Q. Light and adjust torch

R. Silver braze lines into compressor

S. Clean brazed joints with a damp towel

T. Clean off any remaining flux

U. Have instructor check

V. Clean up and put away tools and materials

SEALED SYSTEM COMPONENTS
UNIT II

JOB SHEET #2-INSTALL A LOW SIDE SERVICE STUB ON A RECIPROCAL COMPRESSOR

I. Tools and materials

  A. Domestic refrigeration system

  B. Torch

  C. Sand cloth

  D. Silver brazing alloy

  E. Silver solder flux

  F. Two clean shop towels

  G. Side cutters

  H. Tubing cutter

  I. Ball peen hammer

  J. Swage punch

  K. Copper tubing

  L. Flaring block

  M. Striker

  N. Pinch-off tool

  O. Valve

II. Procedure

  A. Disconnect refrigerator from electrical power

  B. Put on safety glasses

JOB SHEET #2

C. Discharge refrigerant slowly by cutting off end of factory stub (Figure 1)

(CAUTION: Be sure and have adequate ventilation when discharging refrigerant.)

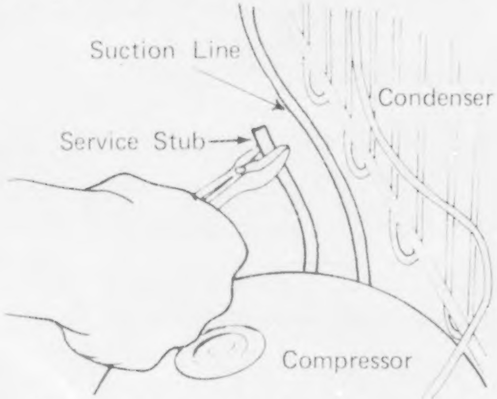


FIGURE 1

D. Place shop towel around the cut off stub

(CAUTION: Do not allow the refrigerant to come into contact with skin or eyes.)

E. Allow the entire refrigerant charge to escape before proceeding

F. Cut off factory stub straight with a tubing cutter

G. Carefully round out stub with swage punch (Figure 2)

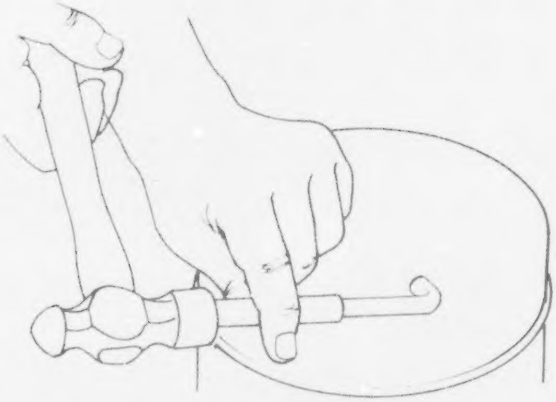


FIGURE 2

H. Do not attempt to swage the compressor stub

I. Cut a piece of clear tubing approximately six inches long

J. Polish one end of the tubing and the compressor stub

JOB SHEET #2

K. Put a thin coating of flux on the tubing

L. Fit the piece of tubing onto or into the compressor stub

M. Turn the tubing in order to coat the compressor stub with flux

N. Light and adjust torch

O. Silver braze extended piece of tubing to compressor stub

P. Clean silver braze joint with a damp shop towel

(CAUTION: Do not get the damp shop towel over the open end of the tubing because some moisture may enter the compressor.)

Q. Check with instructor as to the type of valve that will be used

R. Have instructor check

S. Seal end of service stub with a valve or by crimping and brazing

T. Clean up and put away tools and materials

SEALED SYSTEM COMPONENTS
UNIT II

JOB SHEET #3–INSTALL SERVICE STUBS IN REFRIGERANT LINES

I. Tools and materials

A. Tubing cutter

B. Sand cloth

C. Silver brazing alloy

D. Silver solder flux

E. Torch

F. Striker

G. Clean shop towels

H. Sweat tee

I. Copper tubing

J. Safety glasses

K. Side cutters

L. Pinch-off tool

M. Valve

II. Procedure

A. Disconnect refrigerator from electrical power

B. Put on safety glasses

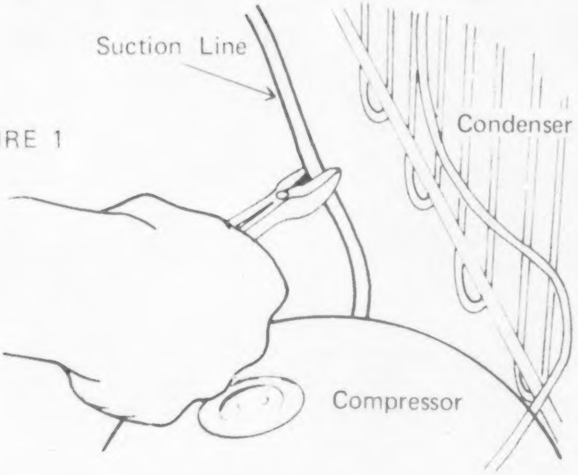
C. Discharge refrigerant slowly

(CAUTION: Be sure and have proper ventilation when discharging refrigerant.)

JOB SHEET #3

D. Suction line may be cut for discharging (Figure 1)

FIGURE 1



E. Place a shop towel under the discharging refrigerant

(CAUTION: Do not allow the refrigerant to come into contact with the eyes or skin.)

F. Allow refrigerant to completely discharge before proceeding

G. Cut suction line with tubing cutter

H. Cut off a short piece of clean tubing

I. Polish the ends of the three pieces of tubing

J. Coat the tubing ends with flux

K. Insert tubing into sweat tee

L. Light and adjust torch

M. Silver braze the three joints

N. Turn off torch

O. Clean the brazed joints with a damp shop towel

(CAUTION: Do not get the damp shop towel over the open end of the short piece of tubing in the tee because some moisture may enter the system.)

JOB SHEET #3

P. Check with instructor as to the type of valves that will be used

Q. Do steps "G" through "O" to the discharge line

R. Have instructor check

S. Seal end of service stub with a valve or by crimping and brazing

T. Clean up and put away tools and materials

SEALED SYSTEM COMPONENTS
UNIT II

JOB SHEET #4 REPLACE A CAPILLARY TUBE

I. Tools and materials

   A. Domestic refrigeration system

   B. Standard slot type screwdriver

   C. Phillips screwdriver

   D. Tubing cutter

   E. Torch

   F. Capillary tube

   G. Striker

   H. Refrigeration gauge set

   I. Dry nitrogen cylinder with regulator

   J. Silver brazing alloy

   K. Silver solder flux

   L. Two shop towels

   M. Soap solution

   N. Brush

II. Procedure

   A. Disconnect refrigerator from electrical power

   B. Put on safety glasses

   C. Discharge refrigerant

   D. Locate capillary tube route

   E. Remove any trim necessary in order to obtain access to the capillary tube

   (NOTE: Be sure all plastic trim is at room temperature before attempting to remove it, to prevent breaking.)

JOB SHEET #4

F. Cut the capillary tube at the outlet of the filter-drier

G. Remove the capillary tube from inlet of the evaporator

H. Light and adjust torch

I. Unsolder capillary tube from suction line

(NOTE: If the capillary tube is not soldered to the suction line for a heat exchange the two previous steps may be eliminated.)

J. Do not get the torch flame close to any plastic trim

K. Straighten out the removed capillary tube

L. Measure the inside diameter of the capillary tube

(NOTE: This may be done with a capillary tube gauge or an orifice drill bit.)

M. Measure the length of the capillary tube

N. Measure the proper length of new capillary tubing and cut

(NOTE: Remember, the method for cutting capillary tubing is to score it and break it off, so the inside diameter of the tubing will not be reduced.)

O. Solder new capillary tube to the side of the suction line with 50-50 solder

P. Insert outlet end of capillary tube into inlet of evaporator

(NOTE: Insert the capillary tube enough to prevent the danger of it becoming restricted with solder. See Figure 1.)

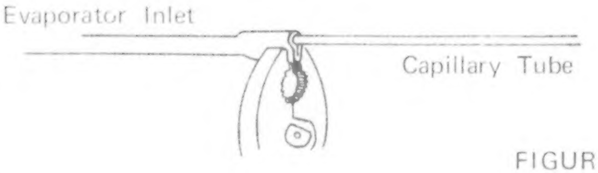


FIGURE 1

Q. Silver braze capillary tube to evaporator

(NOTE: If working with an aluminum evaporator a different type of soldering alloy will have to be used.)

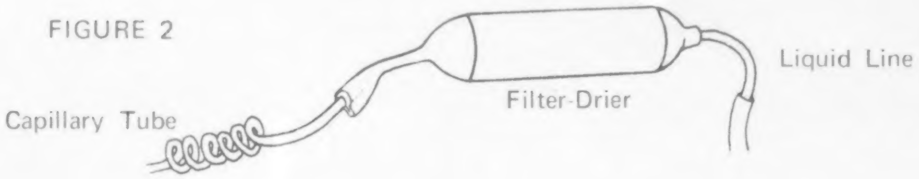
R. Clean flux from silver braze joint

JOB SHEET #4

S. Silver braze capillary tube to filter-drier

(NOTE: The filter-drier is always the last component to be installed in a sealed system repair. See Figure 2.)

FIGURE 2


Capillary Tube
Filter-Drier
Liquid Line

T. Clean flux from filter-drier silver brazed joints

U. Pressurize system

V. Leak check

W. Have instructor check

X. Clean up and put away tools and materials

SEALED SYSTEM COMPONENTS
UNIT II

JOB SHEET #5--INSTALL A LIQUID LINE FILTER-DRIER

I. Tools and materials

- A. Tubing cutter
- B. Torch
- C. Striker
- D. Colored safety glasses
- E. Safety glasses
- F. Refrigeration ratchet wrench
- G. Refrigeration gauge set
- H. Refrigeration system
- I. Filter-drier with sweat fittings
- J. Silver alloy brazing rod
- K. Sand cloth
- L. Silver brazing flux
- M. Damp shop towel
- N. Nitrogen cylinder

II. Procedure

- A. Put on safety glasses
- B. Install refrigeration gauge set
- C. If refrigeration system is under pressure, slowly release pressure
- D. Use the sand cloth and polish the liquid line prior to cutting
- E. Cut liquid line close to the inlet of the metering device
- F. Remove a section of liquid line the length of the filter-drier
- G. Repolish ends after cutting
- H. Apply flux to the polished ends

JOB SHEET #5

I. Remove the protective cap from one end of the filter-drier

(NOTE: On some small filter-driers used for domestic refrigeration, the ends must be cut-off with a tubing cutter.)

J. Check for proper direction of refrigerant flow on filter-drier

K. Insert liquid line into one end of filter-drier

L. Twist the filter-drier while inserting the line to insure sufficient coating of flux

M. Remove protective cap from the other end of the filter-drier

N. Insert the other end of the liquid line

O. Twist the filter-drier while inserting the line

(NOTE: Special precautions are necessary when installing a capillary tube directly into a filter-drier. This procedure is covered in detail on a separate job sheet.)

P. If using a line-drier with an access core type valve, remove the core to prevent the heat from damaging it

Q. Attach nitrogen cylinder to refrigeration gauge set

R. Set nitrogen regulator for 2 p.s.i.g.

S. Allow nitrogen to circulate through the system

T. Put on colored safety glasses

U. Light and adjust torch

V. Apply heat to joint; direct heat away from joint

W. Apply silver brazing alloy

(CAUTION: Cadmium free silver brazing alloy is the recommended alloy to use.)

X. Silver braze the other end

Y. Turn off the torch

Z. Clean the flux from both joints with a damp cloth before the joint cools

AA. Check both joints to be sure all of the flux is removed

BB. Have instructor inspect

CC. Clean up and put tools away

SEALED SYSTEM COMPONENTS
UNIT II

NAME ____________________

TEST

1. Define terms associated with sealed system components.

   a. In-wall condenser--

   b. Plate condenser--

   c. In-wall evaporator--

   d. Cold plate--

2. List the eleven sealed system components of a domestic refrigerator.

   a.

   b.

   c.

   d.

   e.

   f.

   g.

   h.

   i.

   j.

   k.

3. Discuss the functions of the sealed system components in a domestic refrigerator.

a.

b.

c.

d.

e.

f.

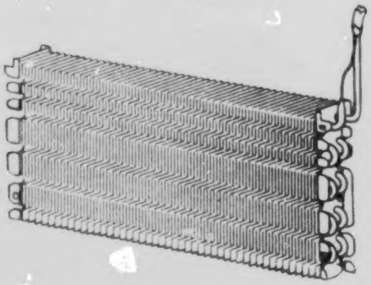
g.

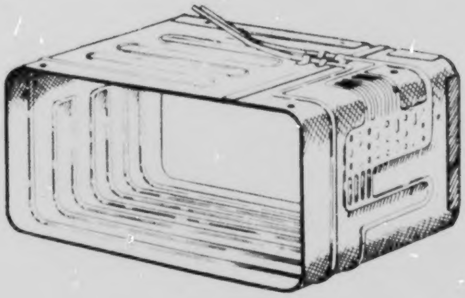
h.

i.

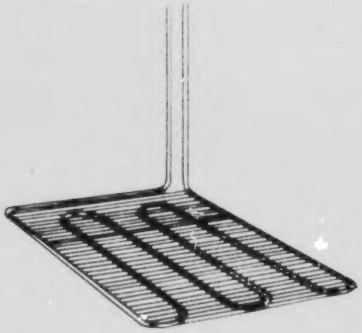
j.

4. Identify the types of evaporators.

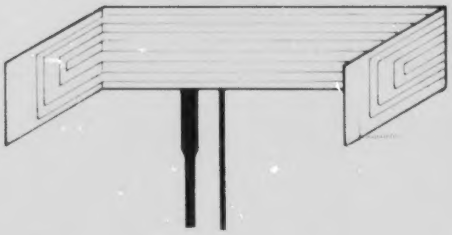




a. ____________________ b. ____________________



c. ____________________



d. ____________________

5. List the five locations of evaporators.

   a.

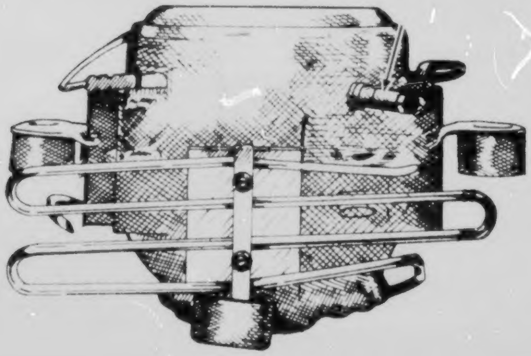
   b.

   c.

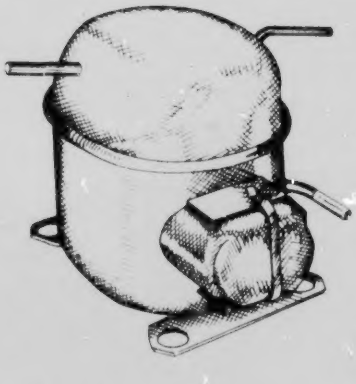
   d.

   e.

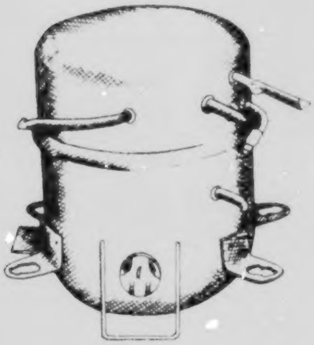
6. Identify the types of compressors.



a. ____________________

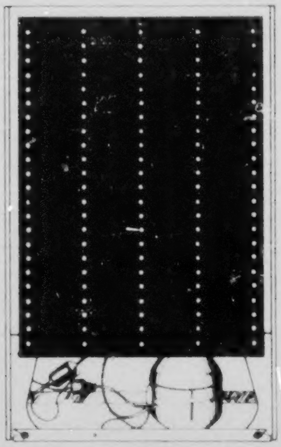


b. ____________________

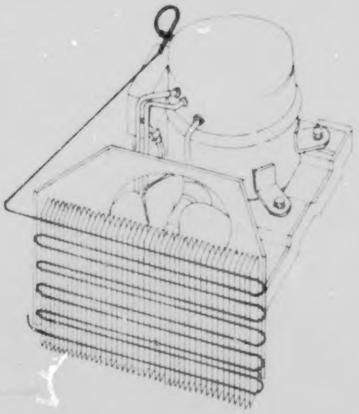


c. ______________________

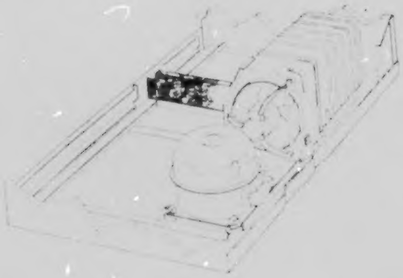
7. Identify the types of condensers.



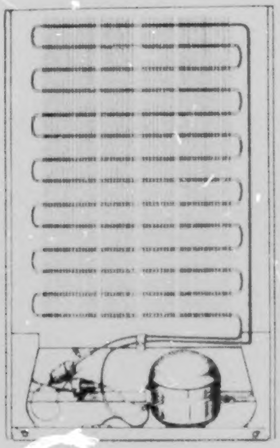
a. ______________________



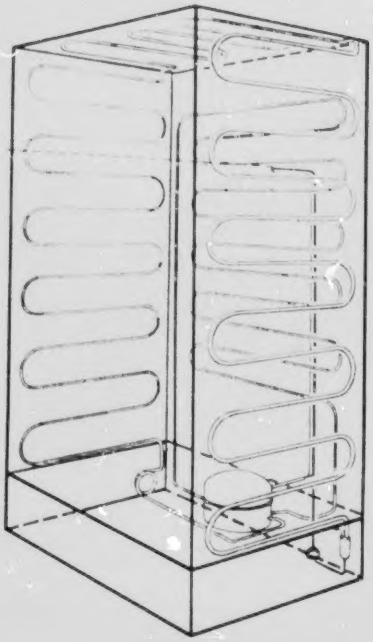
b. ______________________

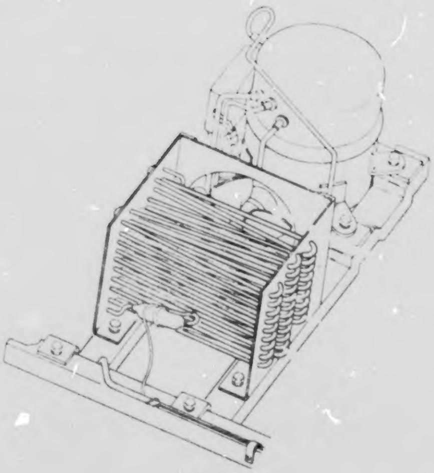


c. ______________________



d. ______________________





e. ______________________ f. ______________________

8. List the three locations of condensers.

   a.

   b.

   c.

9. List the six items of information needed when replacing a capillary tube.

   a.

   b.

   c.

   d.

   e.

   f.

10. Demonstrate the ability to:

    a. Replace a compressor.

    b. Install a low side service stub on a reciprocal compressor.

    c. Install service stubs in refrigerant lines.

    d. Replace a capillary tube.

    e. Install a liquid line filter-drier.

    (NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

SEALED SYSTEM COMPONENTS
UNIT II

ANSWERS TO TEST

1. a. Condenser tubing is attached to the inside walls of the outer liner of the refrigerator or freezer cabinet

   b. Condenser tubing is attached to a sheet metal plate and can be either forced air or static

   c. Evaporator tubing is attached to the outside walls of the inner liner and is used primarily on freezers

   d. Evaporator tubing is attached to a plate

2. a. Compressor

   b. Evaporator

   c. Condenser

   d. Capillary tube

   e. Discharge line

   f. Liquid line

   g. Suction line

   h. Liquid line filter-drier

   i. Accumulator

   j. Oil cooler

   k. Precooler

3. Discussion should include:

   a. Compressor

      1) Lowers pressure in evaporator

      2) Compresses heat laden refrigerant vapor

   b. Evaporator--Transfers heat

   c. Condenser--Dissipates the heat from the refrigerant

   d. Capillary tube

      1) Meters refrigerant into evaporator

      2) Provides a point of expansion

e. Discharge line—Carries the refrigerant from the compressor to the inlet of the condenser

f. Liquid line—Carries the refrigerant from the outlet of the condenser to the inlet of the metering device

g. Suction line—Carries the refrigerant from the outlet of the evaporator to the compressor

h. Liquid line filter-drier

    1) Adsorbs or absorbs moisture from refrigerant

    2) Filters contaminants from refrigerant

i. Accumulator—Prevents liquid refrigerant from entering the compressor

j. Oil cooler—Absorbs heat from compressor oil

4. a. Forced air—Fin

b. Static—Shell

c. Static—Shelf

d. Static—Cold plate

5. a. Entire freezer compartment

b. Back wall of food compartment (cold plate)

c. Back wall of freezer compartment

d. Bottom of freezer compartment

e. Shelves of upright freezer

6. a. Rotary

b. Reciprocal

c. Rotary

7. a. Static plate

b. Forced air fin

c. Forced air plate

d. Static fin

e. Static tube

f. Forced air tube

8. a. In-wall
   b. Back of refrigerator
   c. Underneath refrigerator

9. a. Inside diameter of original capillary tube
   b. Length of original capillary tube
   c. Horsepower of compressor motor
   d. Temperature range of system
   e. Type of refrigerant
   f. Type of condenser

10. Performance skills evaluated to the satisfaction of the instructor

DOMESTIC REFRIGERATION DEFROST AND ELECTRICAL CONTROLS
UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to match terms associated with domestic refrigeration defrost and electrical controls to the correct definitions and discuss the purpose of refrigeration heaters and hot gas and electric defrost components. The student should also be able to replace a temperature control and a defrost heater. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with domestic refrigeration defrost and electrical controls to the correct definitions.
2. List nine domestic refrigerator heaters.
3. Discuss the location of heaters.
4. Discuss the purpose of refrigerator heaters.
5. Identify electrical controls.
6. Discuss the location of electrical controls.
7. Discuss hot gas defrost components.
8. Discuss electric defrost components.
9. List two off-cycle defrost components.
10. Demonstrate the ability to:
    a. Name the heater circuits.
    b. Name the controls.
    c. Diagnose circuit problems.
    d. Replace a temperature control.
    e. Replace a defrost heater.

DOMESTIC REFRIGERATION DEFROST AND ELECTRICAL CONTROLS
UNIT III

SUGGESTED ACTIVITIES

I. Instructor:

  A. Provide student with objective sheet.

  B. Provide student with information, assignment, and job sheets.

  C. Make transparencies.

  D. Discuss unit and specific objectives.

  E. Discuss information and assignment sheets.

  F. Demonstrate and discuss the procedures outlined in the job sheets.

  G. Give test.

II. Student:

  A. Read objective sheet.

  B. Study information sheet.

  C. Complete assignment and job sheets.

  D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

  A. Objective sheet

  B. Information sheet

  C. Transparency masters

    1. TM 1--Heaters

    2. TM 2--Electrical Controls

    3. TM 3--Hot Gas Defrost

D. Assignment sheets

1. Assignment Sheet #1--Name the Heater Circuits

2. Assignment Sheet #2--Name the Controls

3. Assignment Sheet #3--Diagnose Circuit Problems

E. Answers to assignment sheets

F. Job sheets

1. Job Sheet #1--Replace a Temperature Control

2. Job Sheet #2--Replace a Defrost Heater

G. Test

H. Answers to test

II. References:

A. Althouse, Andrew D.; Turnquist, Carl H.; and Bracciano, Alfred F. *Modern Refrigeration and Air Conditioning.* Homewood, Illinois: Goodheart-Willcox Company, Inc., 1975.

B. *Refrigeration, Part II.* Benton Harbor, Michigan: Whirlpool Corp., 1974.

DOMESTIC REFRIGERATION DEFROST AND ELECTRICAL CONTROLS
UNIT III

INFORMATION SHEET

I. Terms and definitions

A. Manual defrost Removing frost accumulation from the evaporator by turning off the refrigerator and allowing the frost to melt

(CAUTION: Do not use a sharp object to remove the frost and ice accumulation.)

B. Automatic defrost--Removing frost accumulation from the evaporator periodically by the use of a timed control and a heat source

C. Electric defrost--Utilization of resistance type heaters in the automatic defrost cycle

D. Hot gas defrost--Routing hot discharge refrigerant to the evaporator for frost removal

E. Cold control--Thermostat which controls cabinet temperature

F. Sweating--Moisture accumulation on cabinet walls

G. Ambient compensator--Small resistance heater located next to the temperature control on a freezer to insure proper cycling

II. Domestic refrigerator heaters (Transparency 1)

A. Defrost heater

B. Drain trough heater

C. Perimeter heater

(NOTE: This may also be called a dew point or cabinet heater.)

D. Air duct heater

E. Fill tube heater

(NOTE: A fill tube heater is used only on some models equipped with ice makers.)

F. Butter keeper heater

G. Ambient compensator

INFORMATION SHEET

   H. Meat keeper heater

   I. Mullion heater

   (NOTE: Not every refrigerator uses all these heaters, but frost-free refrigerators will have the majority of them.)

III. Location of heaters

   A. Defrost heater--Embedded in evaporator fins

   B. Drain trough heater--Underneath defrost water drip trough

   C. Perimeter heater--Behind cabinet door flange

   D. Air duct heater--Inside of air duct

   E. Fill tube heater--Around water inlet tube for ice-maker

   F. Butter keeper heater--Around butter keeper compartment

   G. Ambient compensator--Next to freezer temperature control

   H. Meat keeper heater--Located in cabinet walls around the meat keeper section

   (NOTE: This meat keeper section is only for short storage times.)

   I. Mullion heater--Behind the mullion strip

IV. Purpose of refrigerator heaters

   A. Defrost heater--Automatically removes the frost accumulation from the evaporator

   B. Drain trough heater--Prevents ice build up in the water trough

   C. Perimeter heater--Prevents sweating around cabinet gasket flange

   D. Air duct heater--Prevents ice blockage in the air duct

   E. Fill tube heater--Prevents the water from freezing in water inlet tube

   F. Butter keeper heater--Keeps butter at the proper temperature

   G. Ambient compensator--Warms freezer thermostat for proper cycling

   (NOTE: This is especially useful for freezers that are located where the ambient temperature is lower than the desired cabinet temperature.)

INFORMATION SHEET

- H. Meat keeper heater--Aids in maintaining the proper temperature for meat storage
- I. Mullion heater--Prevents moisture from accumulating on the mullion strip

V. Electrical controls (Transparency 2)

- A. Temperature control thermostat
- B. Relays
  - 1. Hot-wire
  - 2. Current
  - 3. Solid-state
- C. Defrost termination thermostat
- D. Light switch
- E. Fan/light switch
- F. Defrost timer
- G. Overload

VI. Location of electrical controls

- A. Temperature control
  - 1. Side of refrigerator liner
  - 2. Behind air deflector
- B. Starting relay--Attached to or close to the compressor terminals
- C. Defrost termination thermostat--Attached to end of a finned evaporator

  (NOTE: Some refrigerators require two termination thermostats, wired parallel to each other, in order to keep the heater on long enough for proper defrost.)
- D. Light switch--In the side breaker trim on door hinge side of refrigerator (N.C.)
- E. Fan switch--In the side breaker trim on door hinge side of refrigerator (N.O.)

  (NOTE: The light switch and fan switch are usually built into one assembly.)

INFORMATION SHEET

F. Defrost timer—Usually located behind the toe plate

(NOTE: Some manufacturers will place the timer in other locations but it is most often located underneath the refrigerator.)

G. Overload—Next to compressor behind the terminal cover

VII. Hot gas defrost components (Transparency 3)

A. By-pass valve in discharge line

1. Energized—Hot discharge refrigerant by-passes the condenser and metering device

2. Deenergized—Normal refrigerant flow

B. Solenoid—Energizes by-pass valve

C. Control

1. Motor driven timer

2. Ratchet timer

a. Opening and closing freezer door advances timer

b. Remote sensing bulb for termination

VIII. Electric defrost components

A. Motor driven timer

1. Starts defrost cycle

2. Determines length of time compressor is off

(NOTE: Various manufacturers use timers with different defrost cycles. Defrost timer motor running time is determined by unit running time.)

B. Defrost heater

1. Turned on by timer

2. Terminated by

a. Termination thermostat

b. Timer

INFORMATION SHEET

C. Termination thermostat

1. Wired in series with defrost heater only

2. Turns off defrost heater if ambient around evaporator reaches 45° to 50°F

(CAUTION: Do not by-pass the termination thermostat because the heater will come on and stay on the entire length of the timed cycle and could create enough heat to cause excessive damage to the refrigerator.)

D. Drain trough heater

1. Wired parallel to defrost heater and termination thermostat

2. Stays on for entire timed defrost cycle

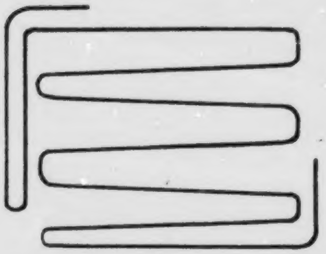
IX. Off-cycle defrost components

A. Defrost heater

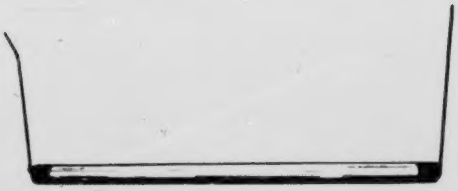
B. Wide range temperature control

(NOTE: Since the defrost heater is only on during the refrigerator off-cycle, a wide range on the temperature control will allow sufficient time for frost removal.)

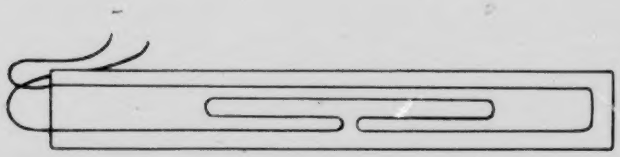
Heaters



Defrost Heater



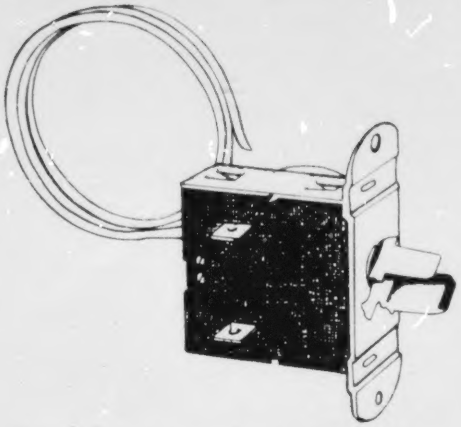
Quartz Heater



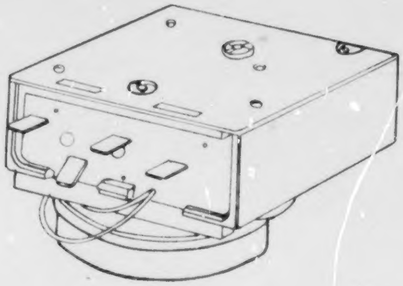
Foil Backed Resistance Heater

(Note : Most Heaters Except The Defrost Heater
Are The Foil Backed Type.)

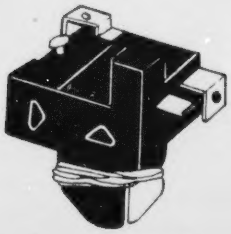
Electrical Controls



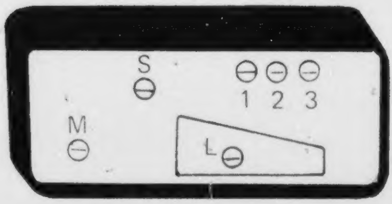
Temperature Control Thermostat



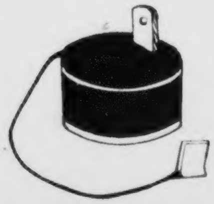
Defrost Timer



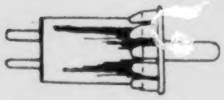
Current Relay



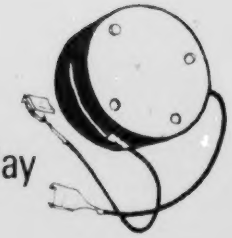
Hot - Wire Relay



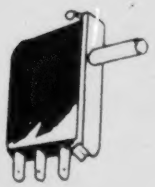
Overload



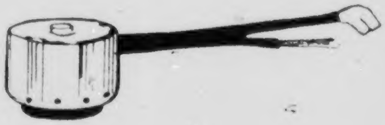
Light Switch



Solid State Relay

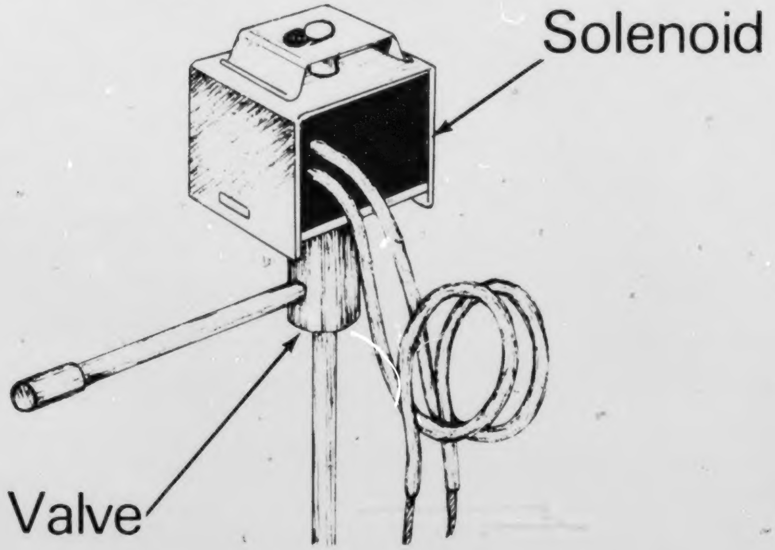


Fan / Light Switch



Defrost Termination Thermostat

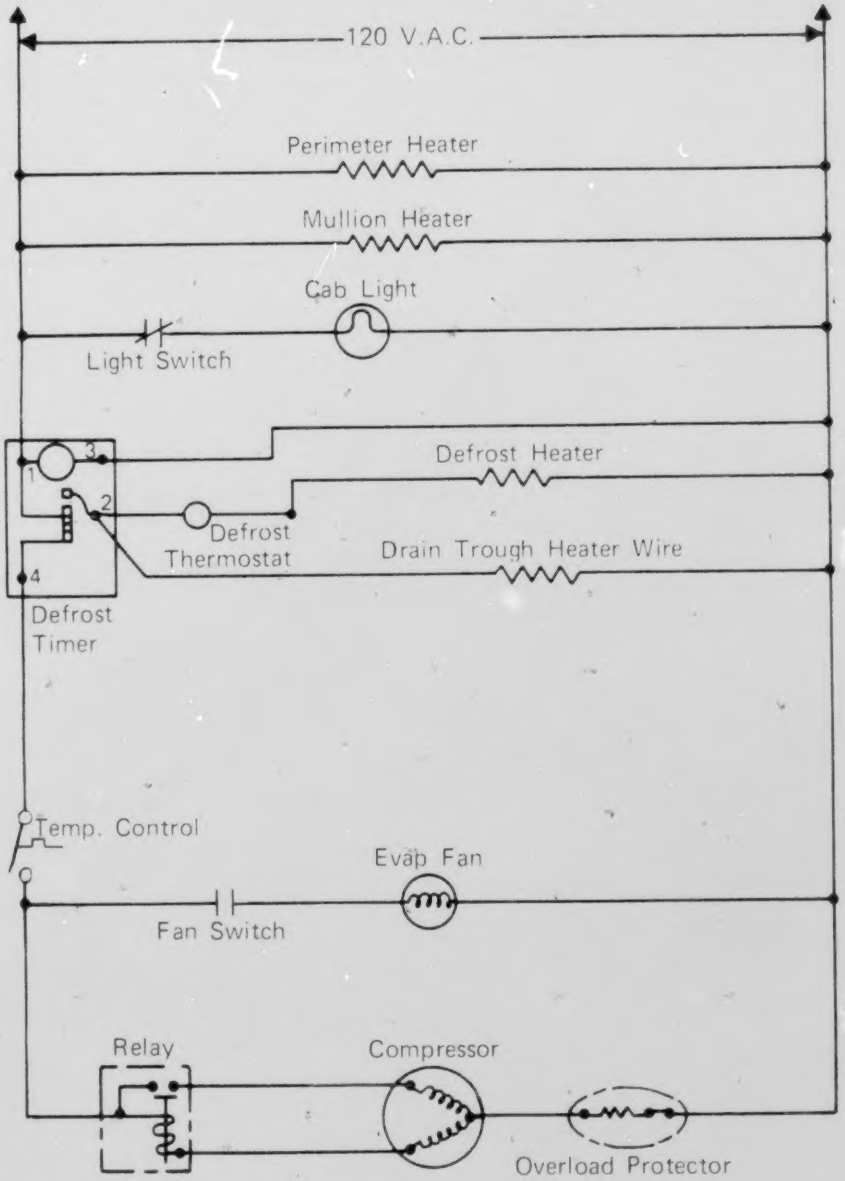
Hot Gas Defrost


Solenoid
Valve

DOMESTIC REFRIGERATION DEFROST AND ELECTRICAL CONTROLS
UNIT III

ASSIGNMENT SHEET #1–NAME THE HEATER CIRCUITS

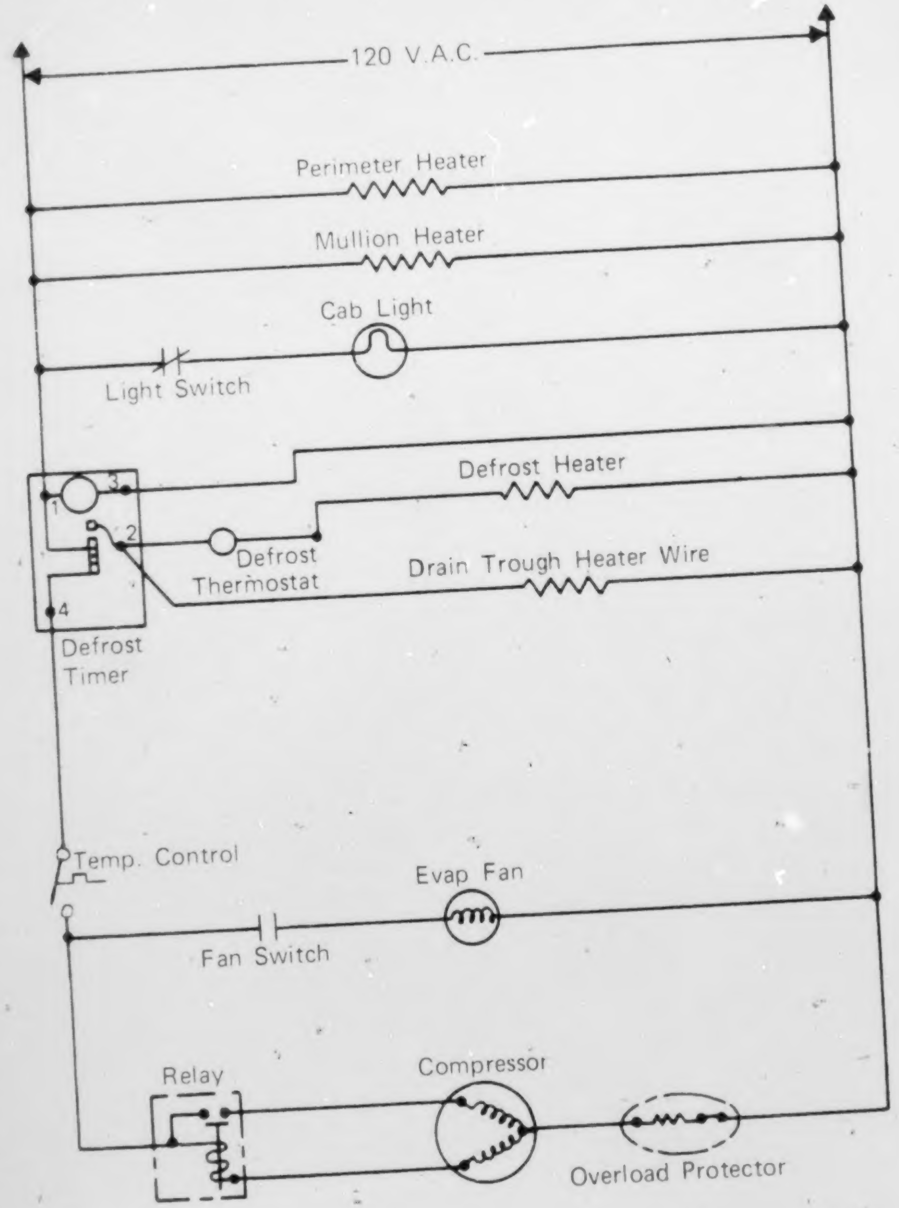
List the heater circuits in the schematic below. A circuit consists of a power source, connecting wiring, load, and sometimes a control.


120 V.A.C.
Perimeter Heater
Mullion Heater
Cab Light
Light Switch
1
3
2
4
Defrost Heater
Defrost Thermostat
Drain Trough Heater Wire
Defrost Timer
Temp. Control
Evap Fan
Fan Switch
Relay
Compressor
Overload Protector

DOMESTIC REFRIGERATION DEFROST AND ELECTRICAL CONTROLS
UNIT III

ASSIGNMENT SHEET #2 NAME THE CONTROLS

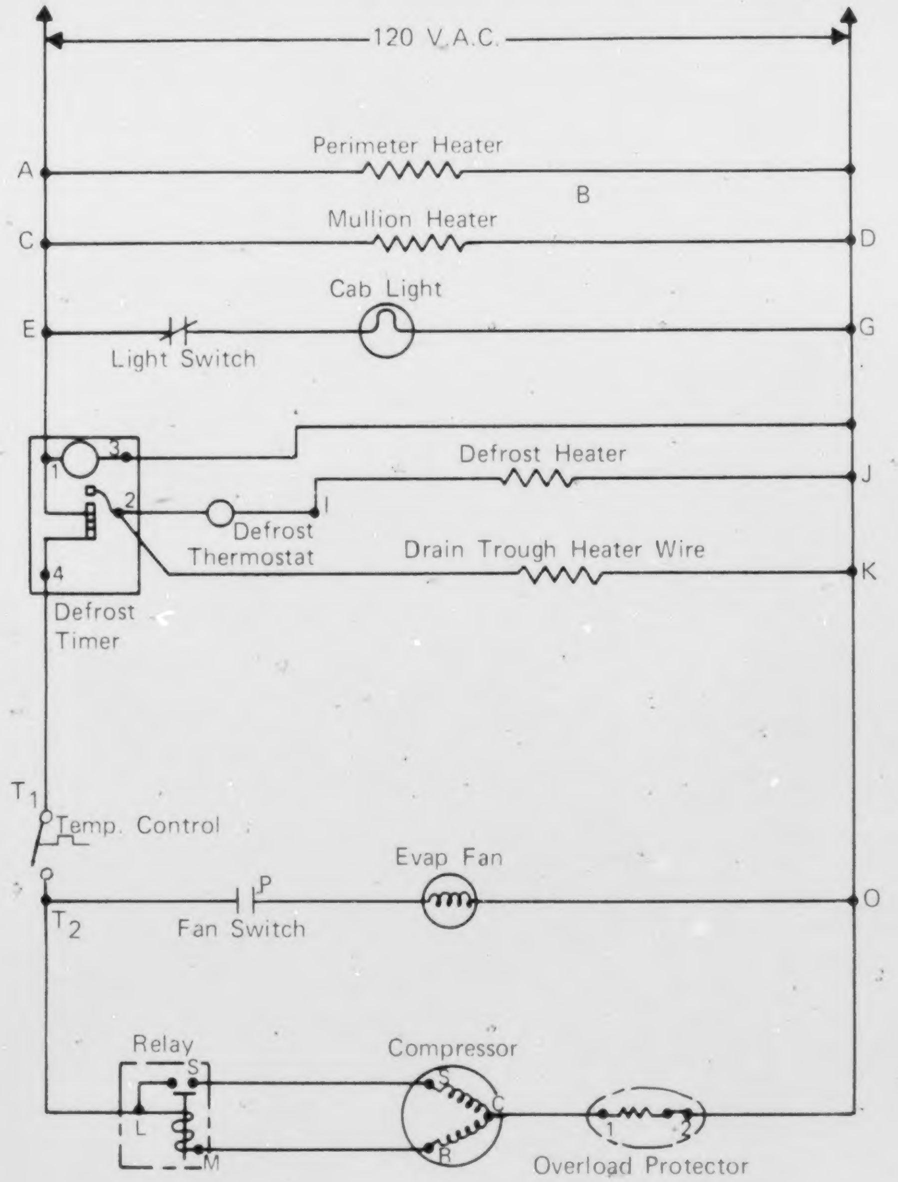
List the controls in the schematic below. A control is in series with a load.


120 V.A.C.
Perimeter Heater
Mullion Heater
Cab Light
Light Switch
Defrost Heater
1
2
3
4
Defrost Thermostat
Drain Trough Heater Wire
Defrost Timer
Temp. Control
Evap Fan
Fan Switch
Relay
Compressor
Overload Protector

DOMESTIC REFRIGERATION DEFROST AND ELECTRICAL CONTROLS
UNIT III

ASSIGNMENT SHEET #3 DIAGNOSE CIRCUIT PROBLEMS

Look at the ladder schematic and answer the questions pertaining to electrical test meter checks.


120 V.A.C.
A
Perimeter Heater
B
C
Mullion Heater
D
E
Cab Light
G
Light Switch
1
3
2
4
Defrost Timer
Defrost Thermostat
I
Defrost Heater
J
Drain Trough Heater Wire
K
T1
Temp. Control
T2
P
Fan Switch
Evap Fan
O
Relay
S
L
M
Compressor
S
C
R
1
2
Overload Protector

ASSIGNMENT SHEET #3

Example: Zero voltage between H and N

No source voltage available.

1. No continuity between A and B

   (NOTE: An in circuit component must have one side disconnected before checking for continuity to prevent getting a reading through another circuit.)

2. 120 V.A.C. between C and D
3. Zero voltage between E and F
4. 120 V.A.C. between F and G
5. Continuity between 1 and 2 on defrost timer

   (NOTE: All continuity checks should be made with the power disconnected.)

6. 120 V.A.C. between 1 on defrost timer and I
7. Current draw between I and J
8. 120 V.A.C. between 2 on defrost timer and K
9. 120 V.A.C. between T_1 and T_2
10. Zero voltage between T_2 and P
11. 120 V.A.C. between L and S
12. No continuity between M on relay and C on compressor
13. 120 V.A.C. between 1 and 2 on overload protector

DOMESTIC REFRIGERATION DEFROST AND ELECTRICAL CONTROLS
UNIT III

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

1. Perimeter heater
2. Mullion heater
3. Defrost heater
4. Drain trough heater

Assignment Sheet #2

1. Light switch
2. Defrost timer
3. Defrost thermostat
4. Temperature control
5. Fan switch
6. Relay

Assignment Sheet #3

1. Open perimeter heater
2. Source voltage is available
3. Light switch is closed
4. Open cabinet light
5. Defrost timer is calling for defrost
6. Defrost timer is not calling for defrost
7. Defrost heater is energized
8. Defrost timer is calling for defrost
9. Temperature control is open

10. Fan switch is closed
11. Relay contacts are open
12. Open compressor run winding
13. Overload bimetal contacts are open

DOMESTIC REFRIGERATION DEFROST AND ELECTRICAL CONTROLS
UNIT III

JOB SHEET #1--REPLACE A TEMPERATURE CONTROL

I. Tools and materials

A. Standard slot type screwdriver

B. Phillips screwdriver

C. Temperature control

D. Temperature recorder

E. Refrigerator

II. Procedure

A. Disconnect electrical power from refrigerator

B. Remove knob from temperature control

(NOTE: Knob should remove easily. If it does not, do not pry on it. On some temperature controls, the center portion of the knob is on a threaded shaft and will have to be removed first.)

C. Remove temperature control mounting screws

D. Pull control out enough to disconnect wires

E. Disconnect sensing element from the evaporator if it is secured to it

F. Carefully remove the sensing element

G. Do not kink or break the sensing element

H. Straighten the sensing element of the new temperature control

I. Insert sensing element

(CAUTION: Be careful not to kink or break the sensing element.)

J. Attach wires to control

K. Place control in proper location

L. Replace mounting screws

JOB SHEET #1

M. Attach sensing element to evaporator in the same manner as the original

N. Check to be sure that the sensing element touches only where intended

(NOTE: If the thermostat sensing element touches a cold spot prior to reaching the evaporator it will cause irratic cycling.)

O. Replace control knob

P. Have instructor check installation

Q. Plug in refrigerator

R. Set temperature control at mid range

S. Place temperature recorder in refrigerator

T. Allow to run for 24 hours

U. Check chart for cycling pattern

V. Have instructor check chart

W. Clean up, and put away tools and materials

DOMESTIC REFRIGERATION DEFROST AND ELECTRICAL CONTROLS
UNIT III

JOB SHEET #2 REPLACE A DEFROST HEATER

I. Tools and materials

  A. Standard slot type screwdriver

  B. Phillips screwdriver

  C. Defrost heater

  D. Refrigerator

  E. Ammeter or wattmeter

II. Procedure

  A. Disconnect electrical power from refrigerator

  B. Open freezer compartment door

  C. Allow freezer compartment to warm up

  D. Remove evaporator cover panel

  E. Remove screws from evaporator mounting brackets

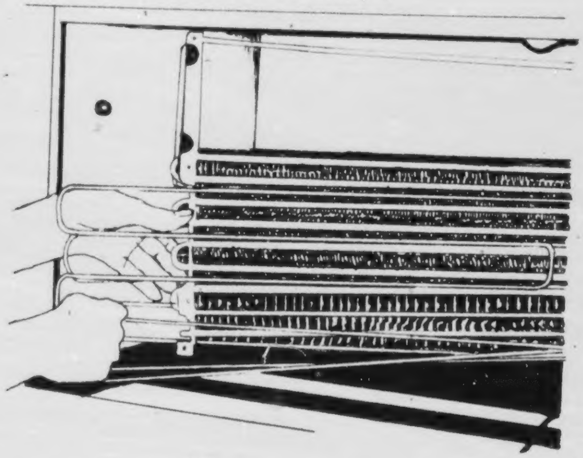
  F. Carefully pull evaporator out enough to make defrost heater accessible

  G. Disconnect defrost heater wiring

  H. Remove heater from evaporator (Figure 1)

  (CAUTION: Be careful when removing or replacing a heater with a finned evaporator, because the fins are sharp.)

FIGURE 1



JOB SHEET #2

I. Install new defrost heater in the evaporator slots

J. Do not push heater into slots with a screwdriver

(NOTE: Using a screwdriver could damage the heater. Flattening one end of a piece 1/2 inch o.d. copper tubing with a V cut in it makes a good heater installation tool.)

K. Connect wiring

L. Check to be sure that no wiring is touching the heater

M. Push evaporator back into position

N. Replace mounting screws

O. Have instructor check installation

P. Replace evaporator cover panel

Q. Plug in refrigerator

R. Set temperature control at mid range

S. Allow the refrigerator to operate long enough to cool down the termination thermostat

T. Set ammeter in highest scale

U. Place ammeter around one conductor of power cord

V. Turn timer shaft in clockwise direction until first click

W. Check ammeter reading

X. Select ammeter scale that provides a center scale reading

Y. Observe ammeter for a reduction in reading when the termination thermostat opens

Z. Check length of time of defrost cycle

(NOTE: The defrost cycle should not be longer than approximately 25 minutes.)

AA. Clean up and put away tools and materials

DOMESTIC REFRIGERATION DEFROST AND ELECTRICAL CONTROLS
UNIT III

NAME ______________________________

TEST

1. Match the terms on the right to the correct definitions.

_____a. Moisture accumulation on cabinet walls

_____b. Utilization of resistance type heaters in the automatic defrost cycle

_____c. Removing frost accumulation from the evaporator by turning off the refrigerator and allowing the frost to melt

_____d. Thermostat which controls cabinet temperature

_____e. Routing hot discharge refrigerant to the evaporator for frost removal

_____f. Removing frost accumulation from the evaporator periodically by the use of a timed control and a heat source

_____g. Small resistance heater located next to the temperature control on a freezer to insure proper cycling

1. Ambient compensator
2. Automatic defrost
3. Sweating
4. Cold control
5. Manual defrost
6. Electric defrost
7. Hot gas defrost

2. List nine domestic refrigerator heaters.

a.

b.

c.

d.

e.

f.

g.

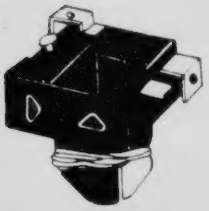
h.

i.

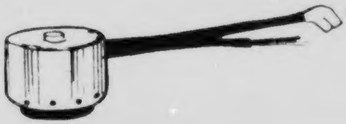
3. Discuss the location of heaters.

4. Discuss the purpose of refrigerator heaters.

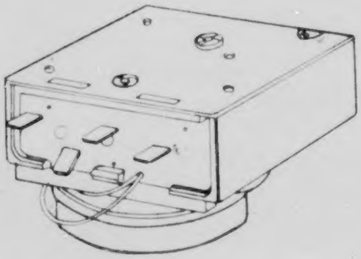
5. Identify the electrical controls.



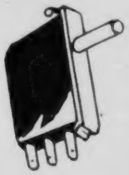
a. ____________________



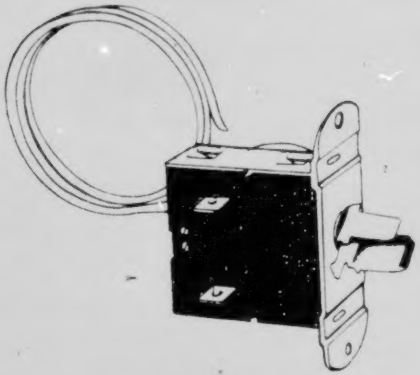
b. ____________________



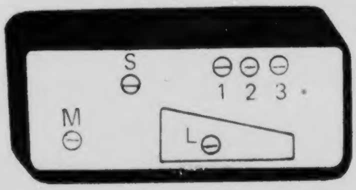
c. ____________________



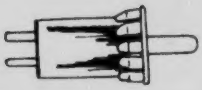
d. ____________________



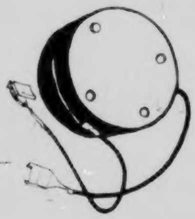
e. ____________________



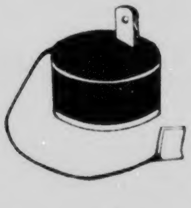
f. ____________________



g. ____________________



i. ____________________



h. ____________________

6. Discuss the location of electrical controls.

7. Discuss hot gas defrost components.

8. Discuss electric defrost components.

9. List two off-cycle defrost components.

   a.

   b.

10. Demonstrate the ability to:

    a. Name the heater circuits.

    b. Name the controls.

    c. Diagnose circuit problems.

    d. Replace a temperature control.

    e. Replace a defrost heater.

    (NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

DOMESTIC REFRIGERATION DEFROST AND ELECTRICAL CONTROLS
UNIT III

ANSWERS TO TEST

1. a. 3
   b. 6
   c. 5
   d. 4
   e. 7
   f. 2
   g. 1

2. a. Defrost heater
   b. Drain trough heater
   c. Perimeter heater
   d. Air duct heater
   e. Fill tube heater
   f. Butter keeper heater
   g. Ambient compensator
   h. Meat keeper heater
   i. Mullion heater

3. Discussion should include:
   a. Defrost heater - Embedded in evaporator fins
   b. Drain trough heater - Underneath defrost water drip trough
   c. Perimeter heater - Behind cabinet door flange
   d. Air duct heater - Inside of air duct
   e. Fill tube heater - Around water inlet tube for ice maker
   f. Butter keeper heater - Around butter keeper compartment
   g. Ambient compensator - Next to freezer temperature control
   h. Meat keeper heater - Located in cabinet walls around the meat keeper section
   i. Mullion heater - Behind the mullion strip

4. Discussion should include:
   a. Defrost heater Automatically removes the frost accumulation from the evaporator
   b. Drain trough heater Prevents ice build up in the water trough
   c. Perimeter heater Prevents sweating around cabinet gasket flange
   d. Air duct heater Prevents ice blockage in the air duct
   e. Fill tube heater Prevents the water from freezing in water inlet tube
   f. Butter keeper heater Keeps butter at the proper temperature
   g. Ambient compensator Warms freezer thermostat for proper cycling
   h. Meat keeper heater Aids in maintaining the proper temperature for meat storage
   i. Mullion heater Prevents moisture from accumulating on the mullion strip
5. a. Current relay
   b. Defrost termination thermostat
   c. Defrost timer
   d. Fan/light switch
   e. Temperature control thermostat
   f. Hot wire relay
   g. Light switch
   h. Overload
   i. Solid state relay
6. Discussion should include:
   a. Temperature control
      1) Side of refrigerator liner
      2) Behind air deflector
   b. Starting relay Attached to or close to the compressor terminals
   c. Defrost termination thermostat Attached to end of a finned evaporator

- d. Light switch In the side breaker trim on door hinge side of refrigerator (N.C.)
- e. Fan switch In the side breaker trim on door hinge side of refrigerator (N.O.)
- f. Defrost timer Usually located behind the toe plate
- g. Overload Next to compressor behind the terminal cover

7. Discussion should include:
   - a. By-pass valve in discharge line
     - 1) Energized Hot discharge refrigerant by-passes the condenser and metering device
     - 2) Deenergized Normal refrigerant flow
   - b. Solenoid Energizes by-pass valve
   - c. Control
     - 1) Motor driven timer
     - 2) Ratchet timer
       - a) Opening and closing freezer door advances timer
       - b) Remote sensing bulb for termination

8. Discussion should include:
   - a. Motor driven timer
     - 1) Starts defrost cycle
     - 2) Determines length of time compressor is off
   - b. Defrost heater
     - 1) Turned on by timer
     - 2) Terminated by
       - a) Termination thermostat
       - b) Timer
   - c. Termination thermostat
     - 1) Wired in series with defrost heater only
     - 2) Turns off defrost heater if ambient around evaporator reaches 45° to 50°F

d. Drain trough heater

1) Wired parallel to defrost heater and termination thermostat

2) Stays on for entire timed defrost cycle

9. a. Defrost heater

b. Wide range temperature control

10. Performance skills evaluated to the satisfaction of the instructor

MECHANICAL SERVICING OF DOMESTIC REFRIGERATORS
UNIT IV

UNIT OBJECTIVE

After completion of this unit, the student should be able to match terms to their correct definitions and list three types of leak detectors, three common mechanical system failures, the characteristics of an overcharged system, and the steps in cleaning a system after burn out. The student should also be able to discuss the indications of a refrigerant leak, characteristics of defective compressor motor valves, characteristics of a restricted capillary tube, and compressor motor burn out. This knowledge will be evidenced through demonstration and by scoring eighty five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Define terms associated with mechanical servicing of domestic refrigerators.
2. List three types of leak detectors.
3. Discuss the indications of a refrigerant leak.
4. List three common mechanical system failures.
5. List the four characteristics of a compressor motor with defective valves.
6. Discuss the characteristics of a restricted capillary tube.
7. List five characteristics of an overcharged system.
8. Discuss compressor motor burn out.
9. List the twelve steps in cleaning a system after burn out.
10. Demonstrate the ability to:
    a. Repair an evaporator with epoxy.
    b. Evacuate and charge a refrigerator which has only a low side service valve.
    c. Evacuate and charge a refrigerator which has only a high side service valve.

d. Clean a system after burn out.

e. Clean a restricted capillary tube.

f. Repair an evaporator by aluminum brazing.

g. Check efficiency of a compressor motor.

MECHANICAL SERVICING OF DOMESTIC REFRIGERATORS
UNIT IV

SUGGESTED ACTIVITIES

I. Instructor:

  A. Provide student with objective sheet.

  B. Provide student with information and job sheets.

  C. Discuss unit and specific objectives.

  D. Discuss information sheet.

  E. Demonstrate and discuss the procedures outlined in the job sheets.

  F. Show the students a burned out compressor motor and a sample of oil from a burned out compressor motor.

  G. Give test.

II. Student:

  A. Read objective sheet.

  B. Study information sheet.

  C. Complete job sheets.

  D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

  A. Objective sheet

  B. Information sheet

  C. Job sheets

    1. Job Sheet #1--Repair an Evaporator with Epoxy

    2. Job Sheet #2--Evacuate and Charge a Refrigerator Which Has Only a Low Side Service Valve

3. Job Sheet #3--Evacuate and Charge a Refrigerator Which Has Only a High Side Service Valve
4. Job Sheet #4--Clean a System After Burn Out
5. Job Sheet #5--Clean a Restricted Capillary Tube
6. Job Sheet #6--Repair an Evaporator By Aluminum Brazing
7. Job Sheet #7--Check Efficiency of a Compressor Motor

D. Test

E. Answers to test

II. References:

A. *Refrigeration Service, Part I.* Benton Harbor, Michigan: Whirlpool Corp., 1974.

MECHANICAL SERVICING OF DOMESTIC REFRIGERATORS
UNIT IV

INFORMATION SHEET

I. Terms and definitions

   A. Contamination-Foreign substance in a refrigeration system such as dirt, moisture, or other foreign matter

   B. Acidic-Condition in which the refrigerant and/or oil becomes corrosive in nature

   C. Compressor motor valves-Internal reed type valves inside the compressor which allow the low pressure refrigerant to enter the compression cylinder and the compressed refrigerant to be discharged

II. Leak detectors

   A. Soap bubbles

   B. Halide torch

   C. Electronic

III. Refrigerant leak indications

   A. Reduced cooling capacity

   B. Definite hissing sound at capillary tube outlet

   C. Evaporator frost pattern is short

   D. Low wattage draw

   E. Oil spots

IV. Mechanical system failures

   A. Defective sealed system components

   B. Refrigerant charge

   C. Restrictions

V. Characteristics of a compressor motor with defective valves

   A. Reduced current consumption

   B. Reduced cooling capacity

   C. Higher than normal suction pressure

   D. Lower than normal discharge pressure

INFORMATION SHEET

VI. Characteristics of a restricted capillary tube

(NOTE: The liquid line filter-drier will sometimes become restricted and it should be checked before condemning the capillary tube. A restricted filter-drier will often be indicated by a definite temperature difference between the inlet and outlet of the drier.)

A. Partial restriction

1. Intermittent hissing sound at capillary tube outlet
2. Partial frosting of evaporator
3. Frost on capillary tube

   (NOTE: This may occur at the point of partial restriction.)
4. Normal high side pressure
5. Lower than normal low side pressure
6. Slower than normal rate of pressure equalization when system shuts off

B. Complete restriction

1. No hissing at capillary tube outlet
2. No frost on evaporator
3. Low compressor wattage
4. Lower than normal high side pressure
5. Low side will be in vacuum
6. Pressures will not equalize when system shuts off

VII. Characteristics of an overcharged system

(NOTE: An overcharged condition is usually the result of an improper previous service operation.)

A. Completely frosted evaporator

B. Frosted suction line

C. Higher than normal compressor wattage

INFORMATION SHEET

D. Above normal head pressure

E. Compressor motor noisy

(NOTE: Excessive overcharge may damage the compressor by slugging.)

VIII. Compressor motor burn out

(NOTE: The refrigerant will have a pungent odor.)

A. Electric motor in compressor motor burns out

B. Creates acid in entire system

C. Compressor motor must be changed

D. System must be flushed

IX. Steps in cleaning a system after burn out

A. Discharge refrigerant

(CAUTION: Do not allow the refrigerant or oil to come in contact with your skin or eyes because it will be acidic.)

B. Remove compressor motor

C. Disconnect inlet and outlet of capillary tube or other metering device

D. Connect capillary tube cleaner to the capillary tube and clean

(NOTE: If a different type of metering device is used it should be disassembled and cleaned.)

E. Flush evaporator with liquid refrigerant

(CAUTION: Wear safety glasses and do not let the liquid contact the skin because it will cause a burn.)

F. Flush condenser with liquid refrigerant

G. Flush suction and liquid lines with liquid refrigerant

(NOTE: The refrigerant used for flushing should be the same as the refrigerant used in the system.)

INFORMATION SHEET

H. Connect outlet of capillary tube to inlet of evaporator

I. Install new compressor motor

J. Install new liquid line filter-drier

K. Triple evacuate

L. Charge with refrigerant

MECHANICAL SERVICING OF DOMESTIC REFRIGERATORS
UNIT IV

JOB SHEET #1-REPAIR AN EVAPORATOR WITH EPOXY

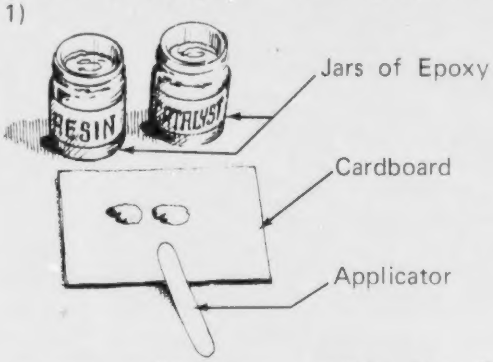
I. Tools and materials

- A. Aluminum evaporator
- B. Sand cloth
- C. Epoxy (which is designed to be used with refrigerant)
- D. Clean piece of cardboard or sheet metal
- E. Acetone
- F. Clean applicator
- G. Drop light
- H. Refrigeration gauge set
- I. Vacuum pump
- J. Shop towels
- K. Dry nitrogen
- L. Soap solution

II. Procedure

- A. Clean surface to be repaired with sand cloth
- B. Clean surface with acetone and a clean shop towel
- C. Put equal amounts of resin and catalyst on a clean piece of cardboard or sheet metal (Figure 1)

FIGURE 1



(NOTE: Only use an epoxy which is compatible with fluorocarbon refrigerants.)

JOB SHEET #1

D. Mix the resin and catalyst together

E. Apply the epoxy to the area to be repaired

F. Place a drop light close to the repaired area

G. Install gauge set

H. Connect vacuum pump

I. Pull approximately 10" Hg. on the system

(NOTE: The heat from the drop light will sometimes cause a slight pressure increase in the sealed system which can create bubbles in the epoxy patch and result in pinhole leaks. A slight vacuum on the system during the drying process will prevent this.)

J. Leave the light on for approximately two hours

K. Allow system to set for twenty-four hours

L. Pressurize with dry nitrogen

M. Check repaired area with soap solution

N. Discharge nitrogen

O. Evacuate

(NOTE: Check with instructor about changing the filter-drier prior to evacuation.)

P. Recharge system with refrigerant

Q. Have instructor check

R. Clean up and put away tools and materials

MECHANICAL SERVICING OF DOMESTIC REFRIGERATORS
UNIT IV

JOB SHEET #2--EVACUATE AND CHARGE A REFRIGERATOR WHICH HAS ONLY A LOW SIDE SERVICE VALVE

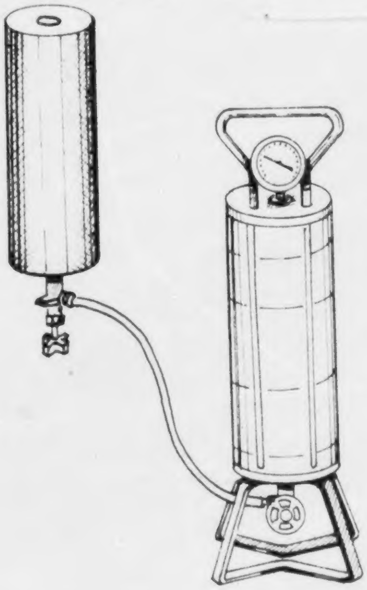
I. Tools and materials

- A. Domestic refrigerator with low side access valve
- B. Refrigeration gauge set
- C. Calibrated charging cylinder
- D. Refrigerant
- E. Clean shop towels
- F. Vacuum pump
- G. Mercury manometer
- H. Safety glasses
- I. Pocket thermometer
- J. Pressure chart
- K. Soap solution

II. Procedure

- A. Put on safety glasses
- B. Put refrigerant into charging cylinder (Figure 1)

FIGURE 1

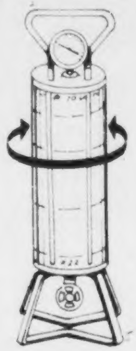


JOB SHEET #2

C. Rotate dial shroud to proper refrigerant and pressure reading (Figure 2)

(NOTE: The drum pressure will be indicated on the gauge which is on top of the charging cylinder.)

FIGURE 2



D. Close charging cylinder valve when refrigerant reaches the desired level

E. Close refrigerant drum valve

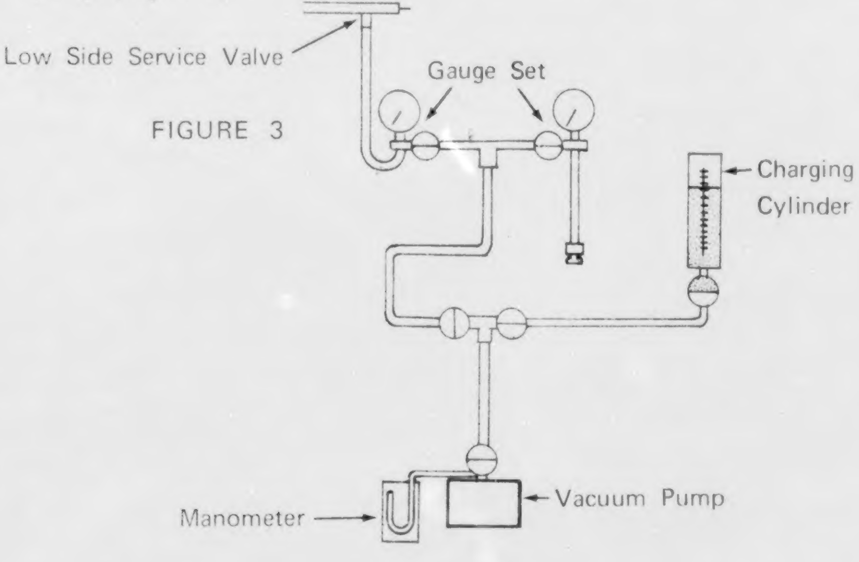
F. Set drum upright

G. Place shop towel around hose and loosen hose

H. Allow refrigerant to purge from hose

I. Connect gauge set to low side service valve, charging cylinder and vacuum pump (Figure 3)

FIGURE 3


Low Side Service Valve
Gauge Set
Charging Cylinder
Manometer
Vacuum Pump

JOB SHEET #2

J. Open low side gauge set valve

K. Open vacuum pump valve

L. Start vacuum pump

M. Properly evacuate

N. Periodically check vacuum pump operation

O. Close low side valve on gauge set

P. Close vacuum pump valve

Q. Allow system to set for approximately ten minutes

R. Check compound gauge for a loss of vacuum

S. Open valve on charging cylinder

T. Crack low side valve on gauge set

(NOTE: Refrigerant should enter the system slowly so as not to wash the oil out of the compressor.)

U. Allow system pressure to rise to approximately 50 p.s.i.g.

V. Start refrigerator

W. Allow the rest of the refrigerant to enter the system slowly

X. Keep the pressure out of vacuum while charging

(NOTE: Systems with rotary compressors will sometimes run in a vacuum for about thirty minutes and gradually come up to the correct low side pressure.)

Y. Close charging cylinder valve

Z. Close low side valve on gauge set

AA. Allow refrigerator to run until freezer compartment is approximately 0°F

BB. Check low side gauge pressure

CC. Check pressure temperature chart

DD. Have instructor check

EE. Remove gauge set

FF. Check service valve with soap solution for possible leaks

GG. Clean up and put away tools and materials

MECHANICAL SERVICING OF DOMESTIC REFRIGERATORS
UNIT IV

JOB SHEET #3 EVACUATE AND CHARGE A REFRIGERATOR WHICH HAS ONLY A HIGH SIDE SERVICE VALVE

I. Tools and materials

  A. Domestic refrigerator with high side service valve

  B. Refrigeration gauge set

  C. Calibrated charging cylinder

  D. Refrigerant

  E. Clean shop towels

  F. Vacuum pump

  G. Mercury manometer

  H. Safety glasses

  I. Open end wrenches

  J. Pocket thermometer

  K. Pressure chart

  L. Soap solution

  M. Valve adapter kit

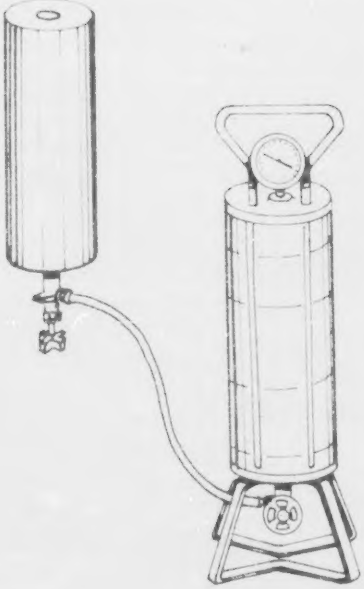
JOB SHEET #3

II. Procedure

A. Put on safety glasses

B. Put refrigerant into charging cylinder (Figure 1)

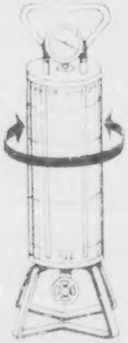
FIGURE 1



C. Rotate dial shroud to proper refrigerant and pressure reading (Figure 2)

(NOTE: The drum pressure will be indicated on the gauge which is on top of the charging cylinder.)

FIGURE 2



D. Close charging cylinder valve when refrigerant reaches the desired level

JOB SHEET #3

E. Close refrigerant drum valve

F. Set drum upright

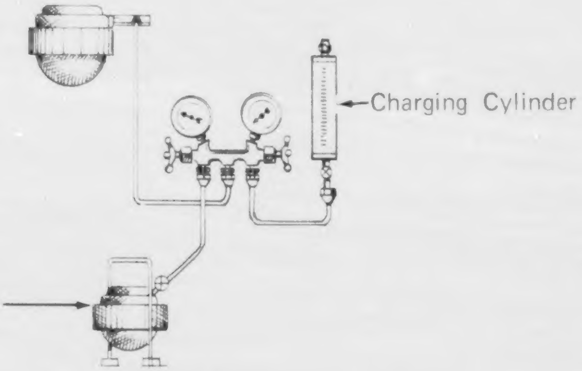
G. Place shop towel around hose and loosen hose

H. Allow refrigerant to purge from hose

I. Connect gauge set to high side service valve, charging cylinder and vacuum pump (Figure 3)

(NOTE: If working with a Frigidare compressor the service valve adapter will have to be installed first.)

FIGURE 3



J. Open high side and low side gauge set valves

K. Open vacuum pump valve

L. Start vacuum pump

M. Properly evacuate

N. Periodically check vacuum pump operation

O. Close vacuum pump valve

P. Allow system to set for approximately ten minutes

Q. Check compound gauge for a loss of vacuum

JOB SHEET #3

R. Close low side valve on gauge set

S. Increase pressure in charging cylinder

(NOTE: Some charging cylinders have a built in heater that can be plugged in. If the cylinder does not have a heater use another heat source such as a drop light or heat gun.)

(CAUTION: Never apply an open flame to any container which has refrigerant in it.)

T. Increase cylinder pressure to a maximum of 150 p.s.i.g.

U. Remove heat from cylinder

V. Open charging cylinder valve

W. Allow all of the refrigerant to enter the system

X. Close charging cylinder valve

Y. Start refrigerator

(CAUTION: Never try to add refrigerant through a high side service valve with the compressor running.)

Z. Allow refrigerator to run until the freezer is 0°F

AA. Check condensing ambient temperature

BB. Check high side pressure reading

CC. Check pressure-temperature chart

DD. Have instructor check

EE. Close or back seat high side service valve

FF. Place shop towel around hose to remove it

(NOTE: If the service valve is of the access core type, place a shop towel around it and remove the hose quickly.)

MECHANICAL SERVICING OF DOMESTIC REFRIGERATORS
UNIT IV

JOB SHEET #4 CLEAN A SYSTEM AFTER BURN OUT

I. Tools and materials

  A. Domestic refrigerator

  B. Refrigerant

  C. Capillary tube cleaner

  D. Torch

  E. Silver solder flux

  F. Sand cloth

  G. Silver brazing alloy

  H. Copper tubing 1/4" o.d.

  I. Flaring tool and block

  J. Tubing cutter

  K. Flare nut 1/4"

  L. Shop towels

  M. Safety glasses

  N. Process tube adapters

  O. Refrigeration gauge set

  P. Refrigerant oil

II. Procedure

  A. Put on safety glasses

  B. Discharge refrigerant

  (CAUTION: Do not allow the refrigerant to touch your skin or eyes as it will contain acid.)

  C. Remove burned out compressor

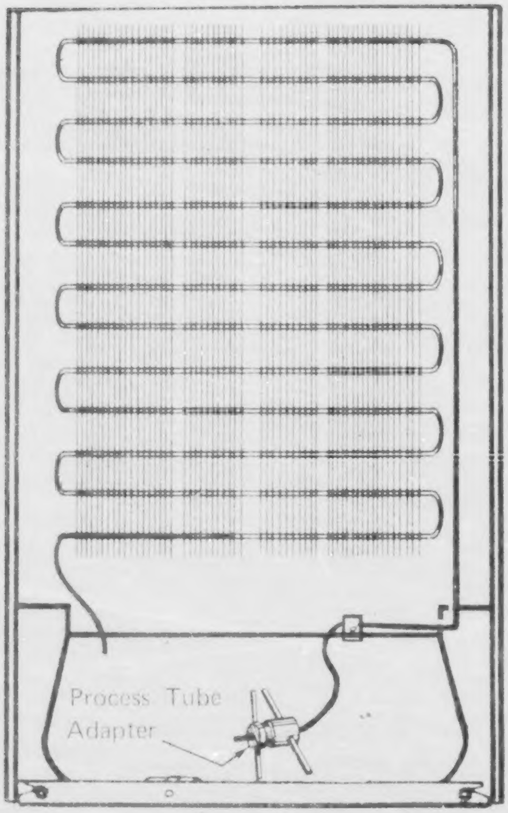
  D. Remove liquid line filter-drier

  E. Disconnect outlet of capillary tube

JOB SHEET #4

F. Place a process tube adapter on discharge line (Figure 1)

FIGURE 1



G. Connect low side gauge hose to adapter

H. Attach center gauge hose to refrigerant drum

I. Open refrigerant drum valve

J. Invert refrigerant drum

K. Place a shop towel over outlet of condenser

L. Open gauge set low side valve

M. Allow liquid refrigerant to flush through condenser

(CAUTION: Be sure that no one is standing nearby that the contaminated refrigerant might hit and that there is no open flames in the area. Ventilate area properly.)

N. Close gauge set low side valve

JOB SHEET #4

O. Remove process tube adapter

P. Place the process tube adapter on the compressor end of the suction line

Q. Place shop towel over open inlet tube of evaporator

R. Flush evaporator with liquid refrigerant

S. Attach capillary tube cleaner to the capillary tube

T. Force clean refrigerant oil through the capillary tube

U. Silver braze capillary tube into inlet of evaporator

V. Install new compressor

W. Install new filter-drier

X. Triple evacuate

Y. Charge with a calibrated charging cylinder

Z. Have instructor check

AA. Clean up and put away tools and materials

MECHANICAL SERVICING OF DOMESTIC REFRIGERATORS
UNIT IV

JOB SHEET #5 CLEAN A RESTRICTED CAPILLARY TUBE

I. Tools and materials

   A. Restricted capillary tube

   B. Capillary tube cleaner

   C. Flat file

   D. Torch

   E. Sand cloth

   F. Silver brazing alloy

   G. Silver solder flux

   H. Copper tubing 1/4" o.d.

   I. Flare nut 1/4"

   J. Shop towels

   K. Two pairs of slip joint pliers

   L. Safety glasses

   M. Tubing cutter

II. Procedure

   A. Put on safety glasses

   B. Straighten the capillary tube

   (NOTE: If a foreign particle is dislodged in the capillary tube it could become lodged again if there is a sharp turn in the capillary tube.)

   C. Score capillary tube one inch in from end with edge of flat file

   D. Place pliers on the capillary tube and break it

   E. Cut a four inch piece of 1/4" copper tubing

   F. Flare one end of 1/4" tubing

JOB SHEET #5

G. Place flare nut on tubing

H. Polish the capillary tube

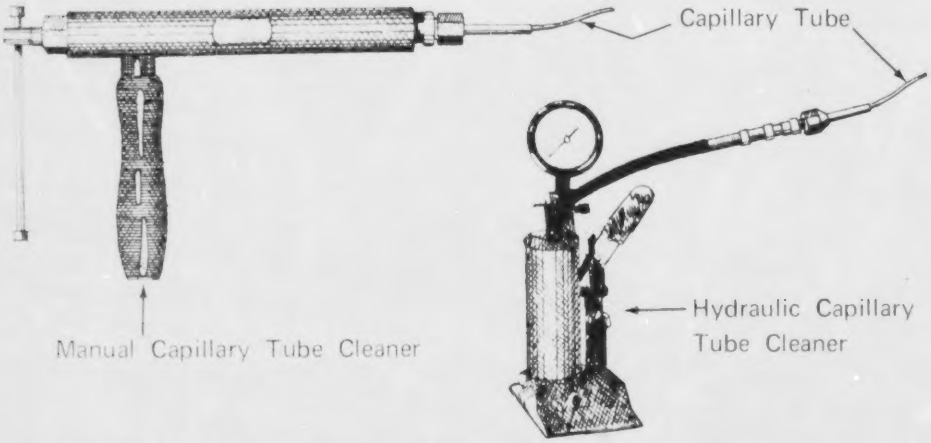
I. Insert capillary tube into opposite end of tubing from flare

J. Crimp tubing

K. Silver braze tubing to capillary tube

L. Attach capillary tube cleaner to flare nut (Figure 1)

FIGURE 1


Capillary Tube
Manual Capillary Tube Cleaner
Hydraulic Capillary Tube Cleaner

M. Have instructor inspect hook up

N. Force oil through the capillary tube

(CAUTION: The gauge on the hydraulic capillary tube cleaner may be damaged if too much pressure is applied. Check with instructor on proper procedure to prevent damage.)

O. Remove the cleaner

(NOTE: The short piece of 1/4" tubing and the flare nut may need to be left on the capillary tube for easy connection to the filter-drier.)

P. Have instructor check

Q. Clean up and put away tools and materials

MECHANICAL SERVICING OF DOMESTIC REFRIGERATORS
UNIT IV

JOB SHEET #6-REPAIR AN EVAPORATOR BY ALUMINUM BRAZING

I. Tools and materials

  A. Aluminum evaporator

  B. Torch

  C. Aluminum brazing rod

  D. Flux

  E. Shop towels

  F. Sand cloth

  G. Safety glasses

II. Procedure

  A. Put on safety glasses

  B. Clean the surface

  (NOTE: The aluminum evaporator should be tilted slightly so that any traces of oil in it will not collect at the heat area.)

  C. Warm one end of the brazing rod

  D. Dip warmed end into the flux

  E. Melt flux off of rod onto area to be brazed

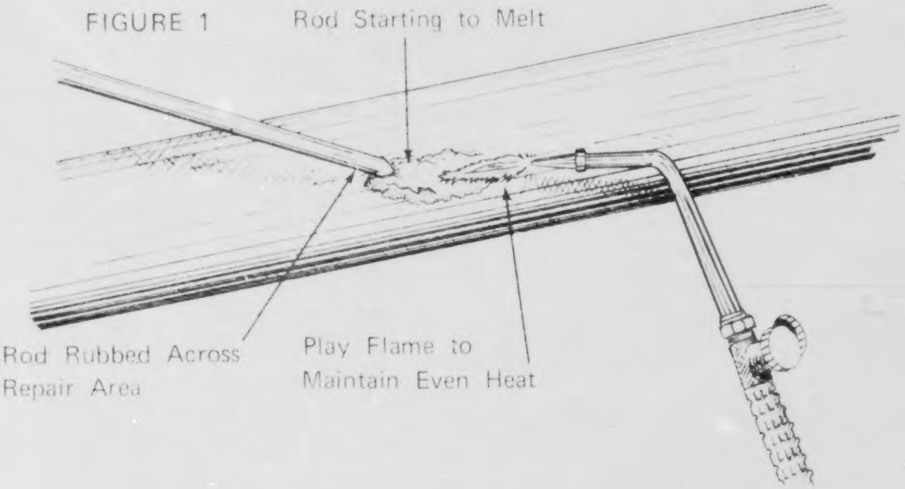
  F. Keep torch in motion and heat rapidly until flux turns to liquid

  G. Melt rod onto the aluminum while keeping the flame on the fluxed area

JOB SHEET #6

H. Scratch the area with the rod as the solder begins to melt (Figure 1)

FIGURE 1


Rod Starting to Melt
Rod Rubbed Across Repair Area
Play Flame to Maintain Even Heat

I. Keep the torch in motion until the entire area to be repaired is covered

J. Allow the solder to cool

K. Remove the flux residue with warm water and a clean cloth

(NOTE: It might be necessary to pressurize and check for leaks.)

L. Have the instructor inspect

M. Clean up and put away tools and materials

MECHANICAL SERVICING OF DOMESTIC REFRIGERATORS
UNIT IV

JOB SHEET #7-CHECK EFFICIENCY OF A COMPRESSOR MOTOR

I. Tools and materials

  A. Domestic refrigerator

  B. Refrigeration gauge set

  C. Ammeter or wattmeter

  D. Safety glasses

  E. Pinch-off tool

  F. Open end wrenches

II. Procedure

  A. Put on safety glasses

  B. Attach gauge set to system

  C. Connect ammeter or wattmeter

  D. Start system

  E. Allow pressures to stabilize

  F. Use pressure-temperature chart to determine the approximate pressures

  (NOTE: An inefficient compressor will be indicated by a combination of:

    1. Higher than normal suction pressure

    2. Lower than normal discharge pressure

    3. Lower than normal current consumption.)

  G. Have instructor inspect

  H. Shut off system

  I. Remove hoses from access valves using a shop towel to protect the skin

  (NOTE: Hoses cannot be purged of refrigerant prior to being removed from an access core type valve.)

  J. Remove temporary tap valves if used

  K. Clean up and put away tools and materials

MECHANICAL SERVICING OF DOMESTIC REFRIGERATORS
UNIT IV

NAME ______________________

TEST

1. Define terms associated with the mechanical servicing of domestic refrigerators.
   a. Compressor motor valves--

   b. Contamination--

   c. Acidic--

2. List three types of leak detectors.
   a.
   b.
   c.

3. Discuss the indications of a refrigerant leak.

4. List three common mechanical system failures.
   a.
   b.
   c.

5. List the four characteristics of a compressor motor with defective valves.

   a.

   b.

   c.

   d.

6. Discuss the characteristics of a restricted capillary tube.

7. List five characteristics of an overcharged system.

   a.

   b.

   c.

   d.

   e.

8. Discuss compressor motor burn out.

9. List the twelve steps in cleaning a system after burn out.

   a.

   b.

   c.

   d.

   e.

   f.

   g.

   h.

   i.

   j.

   k.

   l.

10. Demonstrate the ability to:

    a. Repair an evaporator with epoxy.

    b. Evacuate and charge a refrigerator which has only a low side service valve.

    c. Evacuate and charge a refrigerator which has only a high side service valve.

    d. Clean a system after burn out.

    e. Clean a restricted capillary tube.

    f. Repair an evaporator by aluminum brazing.

    g. Check efficiency of a compressor motor.

    (NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

MECHANICAL SERVICING OF DOMESTIC REFRIGERATORS
UNIT IV

ANSWERS TO TEST

1. a. Compressor motor valves--Internal reed type valves inside the compressor which allow the low pressure refrigerant to enter the compression cylinder and the compressed refrigerant to be discharged

   b. Contamination--Foreign substance in a refrigeration system such as dirt, moisture, or other foreign matter

   c. Acidic--Condition in which the refrigerant and/or oil becomes corrosive in nature

2. a. Soap bubbles

   b. Halide torch

   c. Electronic

3. a. Reduced cooling capacity

   b. Definite hissing sound at capillary tube outlet

   c. Evaporator frost pattern is short

   d. Low wattage draw

   e. Oil spots

4. a. Defective sealed system components

   b. Refrigerant charge

   c. Restrictions

5. a. Reduced current consumption

   b. Reduced cooling capacity

   c. Higher than normal suction pressure

   d. Lower than normal discharge pressure

6. Discussion should include:

   a. Partial restriction

      1) Intermittent hissing sound at capillary tube outlet

      2) Partial frosting of evaporator

      3) Frost on capillary tube

    4) Normal high side pressure
    5) Lower than normal low side pressure
    6) Slower than normal rate of pressure equalization when system shuts off

  b. Complete restriction

    1) No hissing at capillary tube outlet
    2) No frost on evaporator
    3) Low compressor wattage
    4) Lower than normal high side pressure
    5) Low side will be in vacuum
    6) Pressures will not equalize when system shuts off

7. a. Completely frosted evaporator
  b. Frosted suction line
  c. Higher than normal compressor wattage
  d. Above normal head pressure
  e. Compressor motor noisy

8. Discussion should include:
  a. Electric motor in compressor motor burns out
  b. Creates acid in entire system
  c. Compressor motor must be changed
  d. System must be flushed

9. a. Discharge refrigerant
  b. Remove compressor motor
  c. Disconnect inlet and outlet of capillary tube or other metering device
  d. Connect capillary tube cleaner to the capillary tube and clean
  e. Flush evaporator with liquid refrigerant
  f. Flush condenser with liquid refrigerant
  g. Flush suction and liquid lines with liquid refrigerant

   h. Connect outlet of capillary tube to inlet of evaporator
   i. Install new compressor motor
   j. Install new liquid line filter-drier
   k. Triple evacuate
   l. Charge with refrigerant

10. Performance skills evaluated to the satisfaction of the instructor

TROUBLESHOOTING DOMESTIC REFRIGERATORS
UNIT V

UNIT OBJECTIVE

After completion of this unit, the student should be able to define troubleshooting and list the steps in systematic troubleshooting, and preliminary checks to make when troubleshooting domestic refrigerators. The student should also be able to discuss the steps in checking a nonoperative compressor motor and the procedure in troubleshooting a frost-free refrigerator and diagnose refrigerator complaints. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After the completion of this unit the student should be able to:

1. Define troubleshooting.
2. List the seven steps in a systematic approach to troubleshooting.
3. List the six preliminary checks to be made when troubleshooting a refrigerator.
4. Discuss the steps in checking a nonoperative compressor motor.
5. Discuss the procedure in troubleshooting a frost-free refrigerator.
6. Demonstrate the ability to diagnose refrigerator complaints.

TROUBLESHOOTING DOMESTIC REFRIGERATORS
UNIT V

SUGGESTED ACTIVITIES

I. Instructor:

  A. Provide student with objective sheet.

  B. Provide student with information and assignment sheets.

  C. Discuss unit and specific objectives.

  D. Discuss information and assignment sheets.

  E. Design teaching aids to motivate the learning of troubleshooting, such as games like concentration or bingo.

  F. Have students review previous units of instruction such as motors, relays, capacitors, mechanical servicing, defrost and component replacement.

  G. Give test.

II. Student:

  A. Read objective sheet.

  B. Study information sheet.

  C. Complete assignment sheets.

  D. Review previous units.

  E. Practice troubleshooting techniques.

  F. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

  A. Objective sheet

  B. Information sheets

  C. Assignment Sheet #1--Diagnose Refrigerator Complaints

D. Answers to assignment sheet

E. Test

F. Answers to test

II. Reference: *Refrigeration, Part I.* Benton Harbor, Michigan: Whirlpool Corp. 1974.

TROUBLESHOOTING DOMESTIC REFRIGERATORS
UNIT V

INFORMATION SHEET

I. Troubleshooting A systematic approach in determining the causes of equipment failure

II. Steps in a systematic approach to troubleshooting

A. Know the system

B. Talk to the customer

C. Operate the equipment

D. Inspect the equipment

E. List possible causes

F. Reach a conclusion

G. Test your conclusion

III. Preliminary checks to be made when troubleshooting a refrigerator

A. Source voltage available

B. Compressor motor amperage

C. Thermostat contacts closing

D. Clean condenser

(NOTE: The condenser should be cleaned on every refrigerator service job.)

E. Frost accumulation on evaporator

F. Fan motor operation

IV. Steps in checking a nonoperative compressor motor

A. Disconnect refrigerator from power source

B. Remove compressor motor starting components

C. Connect starting test cord

D. If compressor motor starts

INFORMATION SHEET

1. Check thermostat
2. Check defrost timer
3. Check relay
4. Check start capacitor
5. Check wiring

E. If compressor motor won't start, and has no hum:

1. Check start winding
2. Check run winding
3. Check internal overload

(NOTE: If the compressor motor dome is hot allow it time to cool and recheck the motor windings.)

F. If compressor motor hums, but won't start:

1. Compressor motor stuck
    a. Momentarily reverse rotation
    b. Insert start capacitor in circuit
2. Discharge system then try to start

V. Troubleshooting a frost-free refrigerator

(NOTE: A large percentage of the complaints about insufficient cooling of a frost-free refrigerator is due to a malfunction of the automatic defrost.)

A. No source voltage

1. Replace fuse
2. Reset circuit breaker

B. Compressor motor amperage too high

1. Check motor starting components
2. Check compressor motor
3. Check voltage at compressor motor termina's
4. Check refrigerant pressures

INFORMATION SHEET

C. Thermostat contacts not closing

  1. Check thermostat setting

  2. Check sensing element location

  3. Replace thermostat

D. Condenser needs cleaning

  1. Remove all dust and dirt accumulation

  2. Provide adequate air circulation around refrigerator

E. Frost accumulation on evaporator

  1. Manually turn defrost timer into defrost cycle

     (CAUTION: Always turn the timer shaft in a clockwise direction.)

  2. Check amperage

     a. Correct amperage indicates defective timer

     b. No amperage indicates:

        1. Open heater

        2. Open termination thermostat

        3. Open timer contacts

        4. Broken wire

     (NOTE: The termination switch will be open unless the freezer compartment is down to 20°F. Most termination thermostats open at approximately 50°F. and close at approximately 20°F.)

  3. Replace defective components

F. Inoperative fan motors- Replace motor

(NOTE: An evaporator motor that is not running will create a condition similar to a defective defrost circuit and a condenser fan motor will cause the compressor to short cycle.)

TROUBLESHOOTING DOMESTIC REFRIGERATORS
UNIT V

ASSIGNMENT SHEET #1–DIAGNOSE REFRIGERATOR COMPLAINTS

Write in the diagnoses and corrections for the following refrigerator complaints.

1. Compressor motor will not start or hum when connected to a start test cord.

2. Defrost timer must be turned manually to initiate and terminate the defrost cycle.

3. Amperage draw through the wire to the compressor motor start terminal continues until the compressor motor cycles on overload.

4. Compressor motor hums but won't start until the refrigerant is discharged.

5. No source voltage available to the refrigerator.

6. Freezer compartment has cooled down to 25°F and turning the defrost timer shaft clockwise will not energize the defrost heater.

7. Condenser air flow restricted, condenser fins are dirty and there are paper sacks stacked on top of the refrigerator.

8. No air flow in food compartment and the evaporator is frosting heavily.

9. A voltmeter check indicates voltage available to the defrost heater but no heat is being generated.

10. Compressor motor will only hum when connected to the starting test cord.

TROUBLESHOOTING DOMESTIC REFRIGERATORS
UNIT V

ANSWERS TO ASSIGNMENT SHEET

1. Motor winding is probably open. If the compressor motor is equipped with an internal overload allow the compressor motor to cool and recheck.

2. Defective defrost timer. Replace timer.

3. Stuck relay--replace the relay.

4. A high side restriction is creating too much load on the compressor motor.

5. Replace circuit fuse or reset circuit breaker and check refrigerator amperage draw.

6. Termination thermostat has not reset. Allow freezer compartment to cool down below 20°F and recheck.

7. Clean the condenser and remove any objects from around the refrigerator which restrict air flow.

8. Evaporator fan is not running.

9. Defrost heater has an open circuit. Replace defrost heater.

10. Compressor motor is stuck. Attempt to start by reversing rotation or by adding a start capacitor to the circuit.

TROUBLESHOOTING DOMESTIC REFRIGERATORS
UNIT V

NAME ____________________

TEST

1. Define troubleshooting.

2. List the seven steps in a systematic approach to troubleshooting.
   a.
   b.
   c.
   d.
   e.
   f.
   g.

3. List the six preliminary checks to be made when troubleshooting a refrigerator.
   a.
   b.
   c.
   d.
   e.
   f.

4. Discuss the steps in checking a nonoperative compressor motor.
   a.
   b.
   c.

d.
  1.
  2.
  3.
  4.
  5.

e.
  1.
  2.
  3.

f.
  1.
  2.
    a)
    b)

5. Discuss the procedure in troubleshooting a frost-free refrigerator.

a. No source voltage
  1)
  2)

b. Compressor motor amperage too high
  1)
  2)
  3)
  4)

c. Thermostat contacts not closing
  1)
  2)
  3)

d. Condenser needs cleaning

  1)

  2)

e. Frost accumulation on evaporator

  1)

  2)

    a)

    b)

      1)

      2)

      3)

      4)

  3)

f. Inoperative fan motors

6. Demonstrate the ability to diagnose domestic refrigerator complaints

(NOTE: If this activity has not been accomplished prior to the test, ask your instructor when it should be completed.)

TROUBLESHOOTING DOMESTIC REFRIGERATORS
UNIT V

ANSWERS TO TEST

1. A systematic approach in determining the causes of equipment failure
2. a. Know the system
   b. Talk to the customer
   c. Operate the equipment
   d. Inspect the equipment
   e. List possible causes
   f. Reach a conclusion
   g. Test your conclusion
3. a. Source voltage available
   b. Compressor motor amperage
   c. Thermostat contacts closing
   d. Clean condenser
   e. Frost accumulation on evaporator
   f. Fan motor operation
4. a. Disconnect refrigerator from power source
   b. Remove compressor motor starting components
   c. Connect starting test cord
   d. If compressor motor starts:
      1) Check thermostat
      2) Check defrost timer
      3) Check relay
      4) Check start capacitor
      5) Check wiring

- e. If compressor motor won't start, and has no hum:
    - 1) Check start winding
    - 2) Check run winding
    - 3) Check internal overload
- f. If compressor motor hums, but won't start:
    - 1) Compressor motor stuck
        - a) Momentarily reverse rotation
        - b) Insert start capacitor in circuit
    - 2) Discharge system then try to start

5. Discussion should include:

- a. No source voltage
    - 1) Replace fuse
    - 2) Reset circuit breaker
- b. Compressor motor amperage too high
    - 1) Check motor starting components
    - 2) Check compressor motor
    - 3) Check voltage at compressor motor terminals
    - 4) Check refrigerant pressures
- c. Thermostat contacts not closing
    - 1) Check thermostat setting
    - 2) Check sensing element location
    - 3) Replace thermostat
- d. Condenser needs cleaning
    - 1) Remove all dust and dirt accumulation
    - 2) Provide adequate air circulation around refrigerator

e. Frost accumulation on evaporator

  1) Manually turn defrost timer into defrost cycle

  2) Check amperage

    a) Correct amperage indicates defective timer

    b) No amperage indicates:

      (1) Open heater

      (2) Open termination thermostat

      (3) Open timer contacts

      (4) Broken wire

  3) Replace defective components

f. Inoperative fan motors--Replace motor

6. Evaluated to the satisfaction of the instructor.

DOMESTIC REFRIGERATOR ICE MAKERS
UNIT VI

UNIT OBJECTIVE

After completion of this unit, the student should be able to match terms associated with domestic refrigerator ice makers, identify three types of ice makers, wiring diagrams, ice maker parts, and match ice maker problems to checks and remedies. The student should also be able to discuss the operation of ice makers and repair ice makers. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with domestic refrigerator ice makers to the correct definitions or descriptions.
2. Identify three types of ice makers.
3. Identify the pictorial and schematic wiring diagrams for each of the three types of ice makers.
4. Discuss the operation of the crescent shaped cube ice maker.
5. Identify the parts of a crescent shaped cube ice maker.
6. Match the problems of the crescent shaped cube ice maker to the checks and remedies.
7. Discuss the operation of the five cavity ice maker.
8. Identify the parts of the five cavity ice maker.
9. Match the problems of the five cavity ice maker to the correct remedies or checks.
10. Discuss the operation of the flex tray ice maker.
11. Match the problems of the flex tray ice maker to the correct remedies.
12. Identify water valves and components.

13. Demonstrate the ability to:

    a. Install a refrigerator equipped with an ice maker.

    b. Disassemble and clean a water fill valve.

    c. Replace thermostat in a crescent shaped cube ice maker.

    d. Replace mold seal, bearing, and retainer in a five cavity ice maker.

    e. Adjust water valve switch in a flex tray ice maker.

    f. Replace mold heater in a crescent shaped cube ice maker.

DOMESTIC REFRIGERATOR ICE MAKERS
UNIT VI

SUGGESTED ACTIVITIES

I. Instructor:

  A. Provide student with objective sheet.

  B. Provide student with information and job sheets.

  C. Make transparencies.

  D. Discuss unit and specific objectives.

  E. Discuss information sheets.

  F. Demonstrate and discuss the procedures outlined in the job sheets.

  G. Obtain ice makers for demonstration and practice.

  H. Make test cords for operating ice makers.

  I. Give test.

II. Student:

  A. Read objective sheet.

  B. Study information sheets.

  C. Complete job sheets.

  D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

  A. Objective sheet

  B. Information sheets

  C. Transparency masters

    1. TM 1--Ice Makers

    2. TM 2--Wiring Diagrams Crescent Shaped Cube Ice Maker

3. TM 3--Wiring Diagrams Five Cavity Ice Maker
4. TM 4--Wiring Diagrams Flex Tray Ice Maker
5. TM 5--Crescent Shaped Cube Ice Maker
6. TM 6--Crescent Shaped Cube Ice Maker (Continued)
7. TM 7--Crescent Shaped Cube Ice Maker (Continued)
8. TM 8--Crescent Shaped Cube Ice Maker (Continued)
9. TM 9--Crescent Shaped Cube Ice Maker (Continued)
10. TM 10--Crescent Shaped Cube Ice Maker (Continued)
11. TM 11--Crescent Shaped Cube Ice Maker (Continued)
12. TM 12--Crescent Shaped Cube Ice Maker (Continued)
13. TM 13--Parts of the Crescent Shaped Cube Ice Maker
14. TM 14--Parts of the Five Cavity Ice Maker
15. TM 15--Water Valves and Components

D. Job sheets

1. Job Sheet #1--Install a Refrigerator Equipped with an Ice Maker
2. Job Sheet #2--Disassemble and Clean a Water Fill Valve
3. Job Sheet #3--Replace Thermostat in a Crescent Shaped Cube Ice Maker
4. Job Sheet #4--Replace Mold Seal, Bearing, and Retainer in a Five Cavity Ice Maker
5. Job Sheet #5--Adjust Water Valve Switch in a Flex Tray Ice Maker
6. Job Sheet #6--Replace Mold Heater in a Crescent Shaped Cube Ice Maker

E. Test

F. Answers to test

II. References:

A. *Refrigeration, Part II.* Benton Harbor, Michigan: Whirlpool Corp., 1974.

B. *Technical Data Manual Refrigerator Freezer.* General Electric, March 1967.

C. *Refrigerator Service Manual.* Admiral Corp., January, 1969.

DOMESTIC REFRIGERATOR ICE MAKERS
UNIT VI

INFORMATION SHEET

I. Terms and definitions or descriptions

- A. Mold--The component part of most ice makers in which the ice is frozen
- B. Harvest--Depositing ice into the storage bin
- C. Ice stripper--Part on the edge of the crescent shaped cube ice maker mold which prevents the cubes from becoming lodged during harvest
- D. Crescent shape--A half moon shaped object
- E. Cam--Eccentric shaped rotating shaft which operates another mechanism such as a plunger or switch arm

II. Domestic refrigerator ice makers (Transparency 1)

- A. Crescent shaped cube ice maker

  (NOTE: This type of ice maker is used in several different brands of refrigerators, but the patent for it is held by the Whirlpool Corp.)

- B. Five cavity ice maker

  (NOTE: This ice maker is made by General Electric for the exclusive use in General Electric and Hotpoint refrigerators.)

- C. Flex tray ice maker

  (NOTE: There are a couple of versions of this ice maker, but the operation is basically the same.)

III. Pictorial and schematic wiring diagrams (Transparencies 2, 3, and 4)

IV. Operation of the crescent shaped cube ice maker

- A. Water enters ice maker
- B. Water freezes in mold
- C. Ice maker thermostat closes at 18°F
- D. Circuit is completed to motor and mold heater (Transparency 5)

INFORMATION SHEET

E. Motor starts, turning timing cam and ejector blades

F. Timing cam moves holding switch to normally open position (Transparency 6)

G. Ejector blades reach the ice and apply pressure

H. Timing cam raises and lowers the shut-off arm and switches the shut-off switch to normally closed (Transparency 7)

I. Ice is loosened by the mold heater and is scooped out by ejector blades

J. Timing cam closes water valve switch (Transparency 8)

(NOTE: The thermostat is still closed which creates a parallel circuit and since current will take the least path of resistance the water valve solenoid will not energize yet.)

K. First revolution ends with ice resting on blades (Transparency 9)

L. Thermostat remains closed

M. Timing cam actuates holding switch to normally closed position

N. Second revolution begins

(NOTE: Earlier models of this ice maker (prior to 1965) only made one revolution per cycle.)

O. Timing cam again moves holding switch to the normally open position (Transparency 10)

P. Shut-off arm raises and lowers switching shut off switch to normally closed position

Q. Ice is dumped into storage bin

R. Ice maker thermostat opens 50°F (Transparency 11)

S. Mold heater is disconnected

T. Timing cam closes water valve switch (Transparency 12)

U. Water valve solenoid is energized

V. Water enters the ice maker mold

INFORMATION SHEET

W. Timing cam actuates holding switch to normally closed position

(NOTE: If the ice bin is full, preventing the shut-off arm to lower, the shut-off switch will not return to the normally open position and another cycle will not begin.)

V. Parts of a crescent shaped cube ice maker (Transparency 13)

A. Front cover

B. Mounting plate

C. Motor

D. Water valve switch

E. Holding switch

F. Timing cam

G. Thermostat clamp

H. Thermostat

I. Lever arm

J. Shut-off arm spring

K. Support

L. Shut-off switch

M. Gasket

N. Shut-off arm

O. Mold heater

P. Mold

Q. Ejector

R. Ice stripper

S. Water inlet

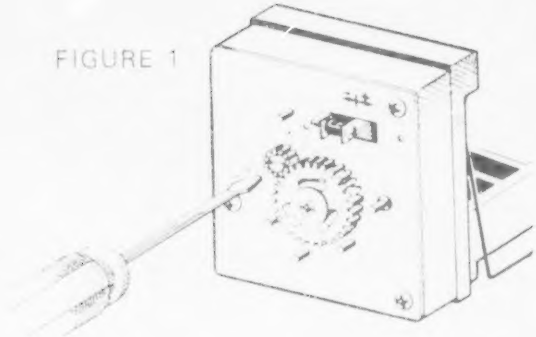
INFORMATION SHEET

VI. Crescent shaped cube ice maker problems, checks, and remedies

A. Ice maker won't start

1. Lower shut-off arm to lowest position
2. Check for voltage to ice maker
3. Check freezer temperature; should be 10°F or less
4. Start motor manually (Figure 1)

FIGURE 1



5. If motor runs after manual start, check:

   (NOTE: When making continuity checks be sure ice maker is disconnected from power source.)

   a. Thermostat for continuity
   b. Continuity "C" to "NC" of holding switch

      (NOTE: Ejector blade should be in the starting position when making this check.)

   c. Continuity "C" to "NO" on shut-off switch
   d. Operation of motor with test cord

B. Ice maker fails to complete cycle

1. Ejector blades stopped at 10 o'clock position
   a. Check holding switch
   b. Switch plunger depressed

INFORMATION SHEET

        c. Should have continuity between "C" and "NO"
        d. Replace switch if open
    2. Ejector blades stopped at 12 o'clock position
        a. Check shut-off switch
        b. Should have continuity between "C" and "NC"
        c. Replace if open
    3. Ejector blades stopped at 4 o'clock position
        a. Check heater and thermostat for continuity
        b. Replace the open component

(NOTE: If the ejector blades will not stop at end of cycle the holding switch is defective.)

C. Undersized ice cubes
    1. Check mold for level
    2. Check screen in water valve
    3. Adjust water valve switch
    4. Check bond between thermostat and mold
    5. Check for corrosion at saddle valve

D. Water spills from mold
    1. Check mold for level
    2. Check for leak between fill tube and water inlet
    3. Check water valve for leaking water through valve when not energized
    4. Adjust water switch

E. Water fails to enter mold
    1. Check freezer temperature
    2. Check water supply components
    3. Check fill tube for ice blockage
        a. Check water valve for seepage

INFORMATION SHEET

b. Check fill tube heater for continuity

(NOTE: Not all refrigerators are equipped with fill tube heaters.)

4. Check water valve solenoid for continuity

5 With the plunger out on the water valve switch, check for continuity between "C" and "NC"

VII. Operation of the five cavity ice maker

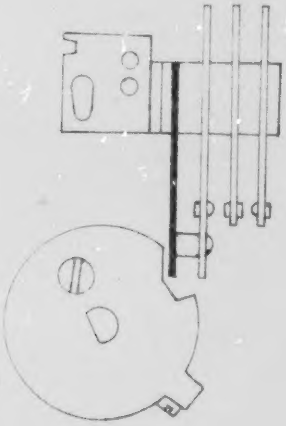
A. Water enters ice maker

B. Water freezes in the mold

C. Ice maker thermostat closes at 16°F

D. Leaf switch contacts are open during freezing (Figure 1)

FIGURE 1



E. Thermostat closing completes circuit to motor and mold heater

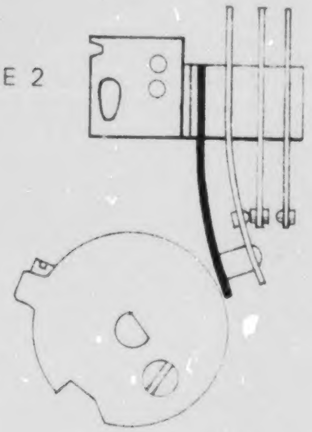
F. Motor stalls until the ice is loosened by the heater

INFORMATION SHEET

G. Cam rotates closing leaf switch #1 (Figure 2)

(NOTE: The closing of switch #1 bypasses the thermostat and the motor operates regardless of the position of the thermostat.)

FIGURE 2

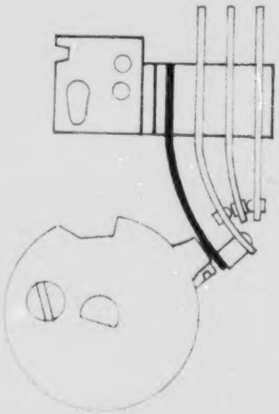


H. Cubes are raised from the mold

I. Cubes are swept into the bin by the rake assembly

J. Cam rotates closing leaf switch #2 (Figure 3)

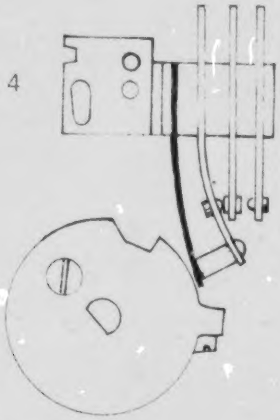
FIGURE 3



INFORMATION SHEET

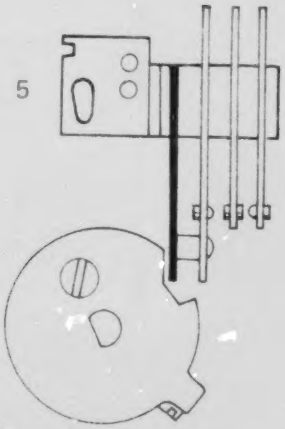
K. After approximately six seconds switch #2 opens (Figure 4)

FIGURE 4



L. The actuator leaf falls into open area on the cam terminating the cycle (Figure 5)

FIGURE 5



VIII. Parts of the five cavity ice maker (Transparency 14)

A. Mechanism cover

B. Power cord

C. Test receptacles

D. Terminal shield

E. Feeler arm

F. Mold shield

G. Fill cup

INFORMATION SHEET

H. Rake link arm
I. Rake spring
J. Rake interlock
K. Rake pivot
L. Rake assembly
M. Ejection pad
N. Mold bracket
O. Seal assembly
P. Mold assembly
Q. Operating thermostat
R. On/Off lever
S. Plate
T. Thermostat clip
U. Actuator rod
V. Actuator assembly
W. Actuator spring
X. Rake fulcrum
Y. Feeler arm switch
Z. Leaf switch
AA. Switch insulator
BB. Motor assembly
CC. Pivot spring
DD. Pivot stud
EE. Feeler arm and rake lever
FF. Cam assembly
GG. Rod-rake connector

INFORMATION SHEET

HH. Ejector lever arm

II. Shoulder screw

JJ. Mold heater

KK. Ejector rod

LL. Finned duct

MM. Safety thermostat

IX. Five cavity ice maker problems, checks, and remedies

A. Not making ice

1. No source voltage to ice maker
2. Manual switch turned off
3. Check for adequate water supply
4. Feeler arm not down
5. Feeler arm switch defective or out of adjustment
6. Safety thermostat open
7. Operating thermostat open--check freezer temperature
8. Leaf switch broken or out of adjustment
9. Defective water valve solenoid
10. Defective motor

B. Makes too much ice

1. Feeler arm broken
2. Feeler arm switch defective or out of adjustment

C. Water overfills

1. Leaky water valve
2. Cubes not ejecting properly
3. Water fill time too long

INFORMATION SHEET

  4. Fill tube out of place
  5. Leaking ejector rod seal
  6. Ice maker not level
  7. Thermostat stuck closed
  8. Leaf switch contacts stuck closed

D. Will not eject cubes

  1. Stuck ejector rod
  2. Broken shoulder screw
  3. Broken rake assembly

E. Will not fill with water

  1. Defective water valve solenoid
  2. Bent leaf switch
  3. Restricted water supply
  4. Plugged water valve screen
  5. Ice in fill tube
  6. Loose or broken wire

F. Cubes too small

  1. Water fill time to short
  2. Low water pressure
  3. Partially restricted water valve screen
  4. Check for corrosion at saddle valve

X. Operation of the flex tray ice maker

  A. Water enters ice tray
  B. Water freezes in tray
  C. Ice maker thermostat closes at 15°F
  D. Thermostat moves a lever arm which actuates motor switch

INFORMATION SHEET

- E. Motor starts turning gear mechanism
- F. Sensor arm moves down into cube storage bin

  (NOTE: If the storage bin is full the cycle will stop. If the storage bin is not full the arm will return to its original position and the cycle will continue.)

- G. Cube tray begins to rotate
- H. At approximately 180 degrees one corner of the tray contacts a stop
- I. Shaft continues to turn twisting the tray
- J. Tray stop is retracted
- K. Tray is rapidly released from its twisted position shaking the cubes into the storage bin
- L. Tray continues to turn until it has completed a 360 degree revolution
- M. Water fill switch is energized

XI. Flex tray ice maker problems, checks, and remedies

- A. Ice maker will not start
  1. Check freezer temperature; should be 15°F or less
  2. Check position of sensor arm
  3. Defective sensing element
  4. Defective motor control switch
  5. Check wiring and connector plug
- B. Cubes stuck together in storage bin
  1. Freezer temperature control set to high
  2. Defective sensing element
  3. Broken sensing element spring
  4. Broken spring on motor switch actuator
- C. Water spills from mold
  1. Check mold for level
  2. Check placement of water fill tube

INFORMATION SHEET

3. Check for leaky water valve
4. Adjust water fill switch
5. Cubes not being ejected

D. Water fails to enter ice tray

1. Check for restriction in water line and valve filter-screen
2. Check for ice in fill tube
3. Check water valve solenoid for open circuit
4. Check water valve switch
5. Check wiring and connector plug

E. Makes too much ice

1. Check actuator sensor arm
2. Check for pin of switch actuator to be in groove of final stage timing gear

F. Undersized ice cubes

1. Check mold for level
2. Check for restrictions in water supply
3. Adjust water fill switch
4. Check for corrosion at saddle valve

XII. Water valves and components (Transparency 15)

A. Saddle valve

(NOTE: The saddle valve is on the supply water line.)

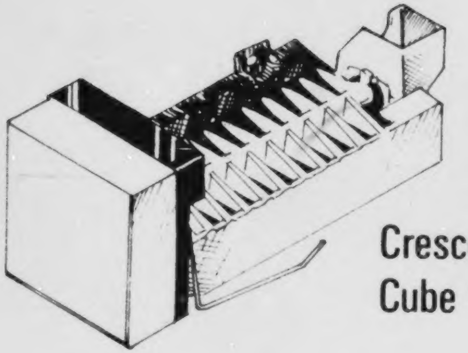
B. Fill valve

1. Filter screen
2. Flow washer
3. Solenoid coil
4. Valve body

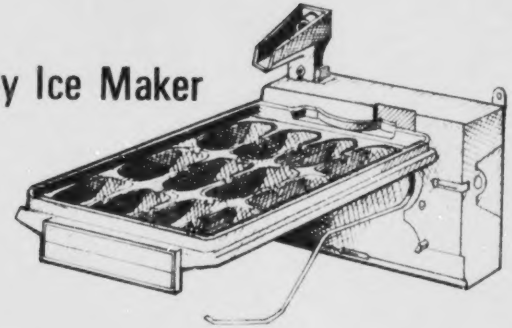
INFORMATION SHEET

5. Diaphragm
6. Armature
7. Spring
8. Guide

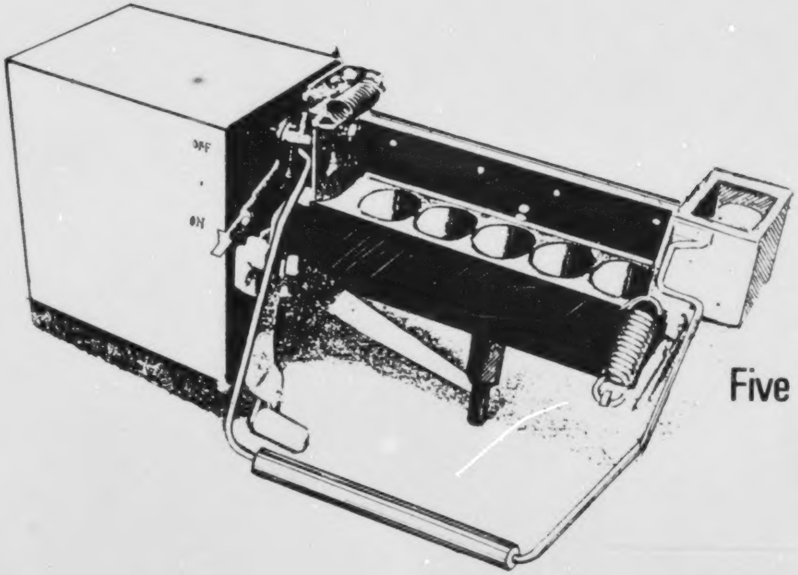
Ice Makers



Crescent Shaped Cube Ice Maker



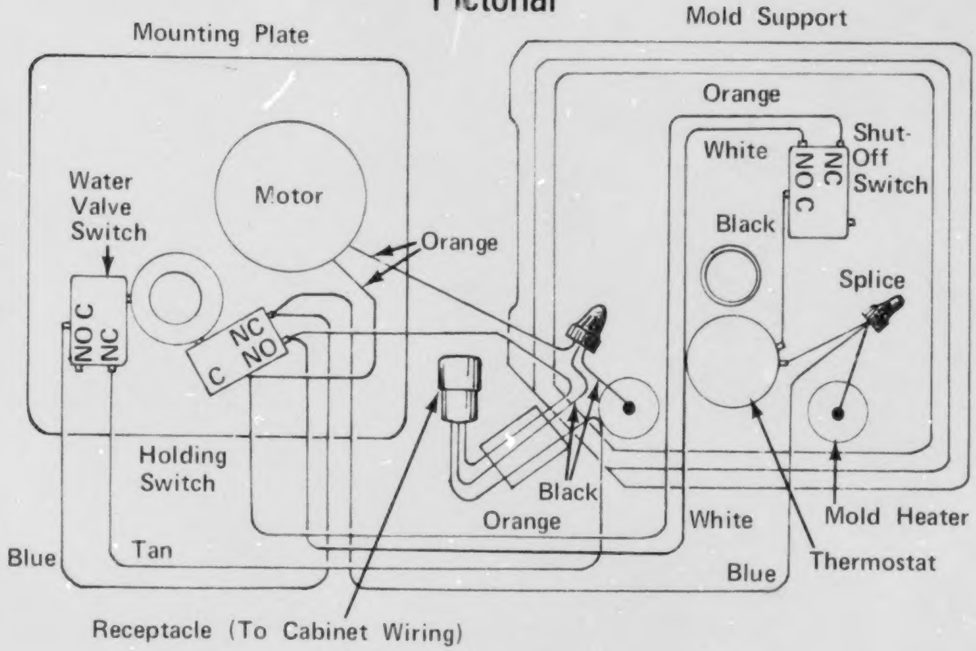
Flex Tray Ice Maker



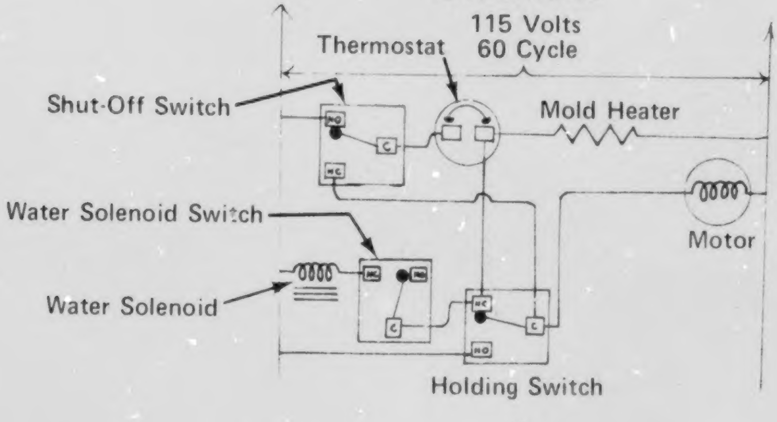
Five Cavity Ice Maker

Wiring Diagrams
Crescent Shaped Cube Ice Maker

Pictorial

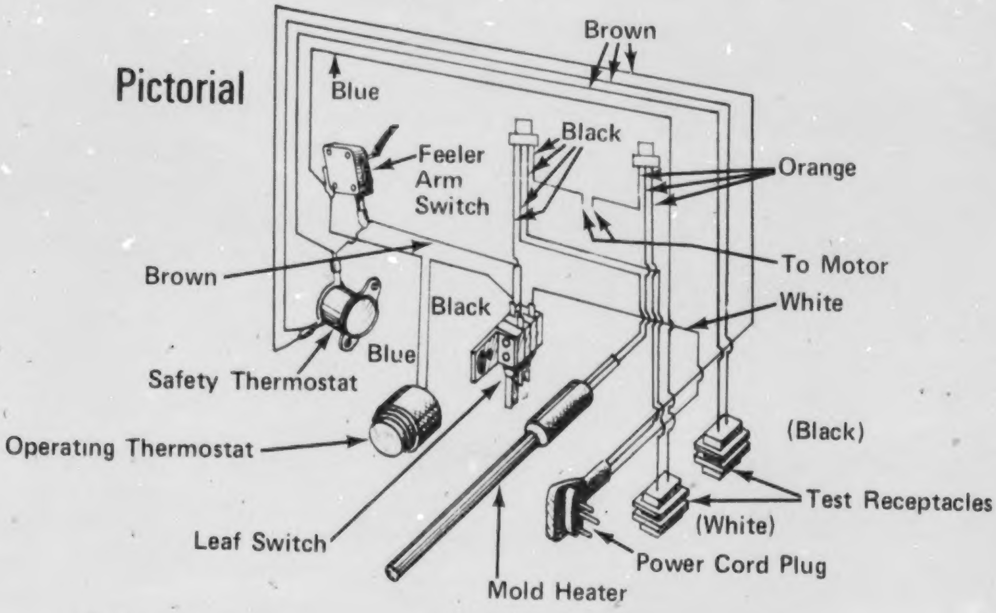

Mounting Plate
Mold Support
Orange
White
Shut-Off Switch
NC
NO
C
Motor
Water Valve Switch
NO C
NC
Black
Orange
Splice
NC
NO
C
Holding Switch
Black
Orange
White
Mold Heater
Thermostat
Blue
Tan
Blue
Receptacle (To Cabinet Wiring)

Schematic

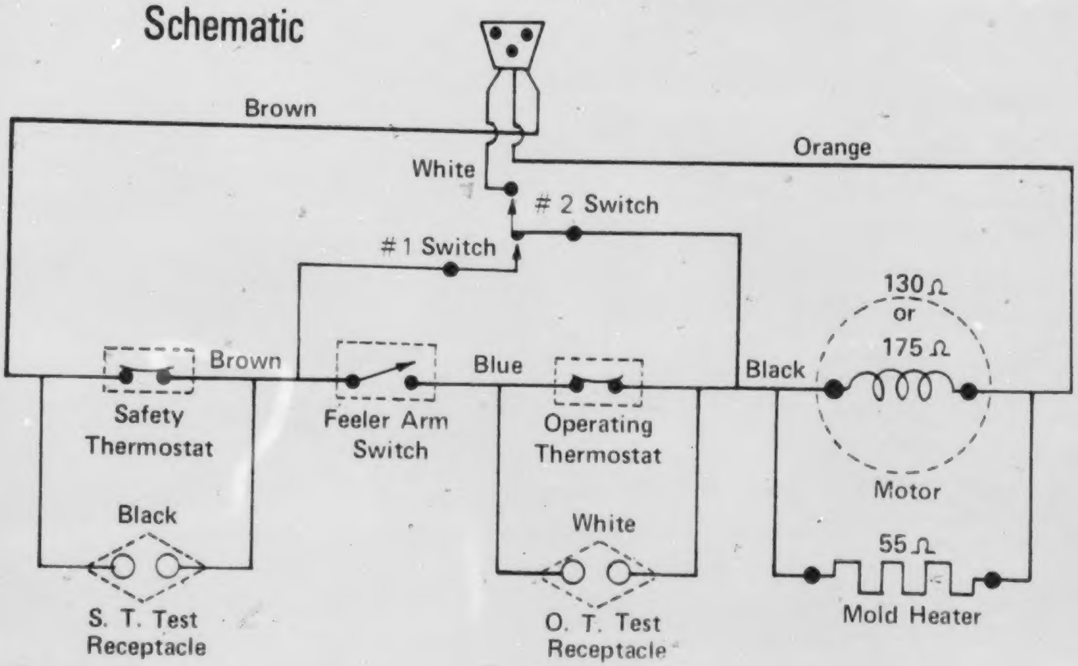

115 Volts
60 Cycle
Thermostat
Shut-Off Switch
NO
C
NC
Mold Heater
Motor
Water Solenoid Switch
NC
NO
C
Water Solenoid
NC
C
NO
Holding Switch

Wiring Diagrams
Five Cavity Ice Maker

Pictorial

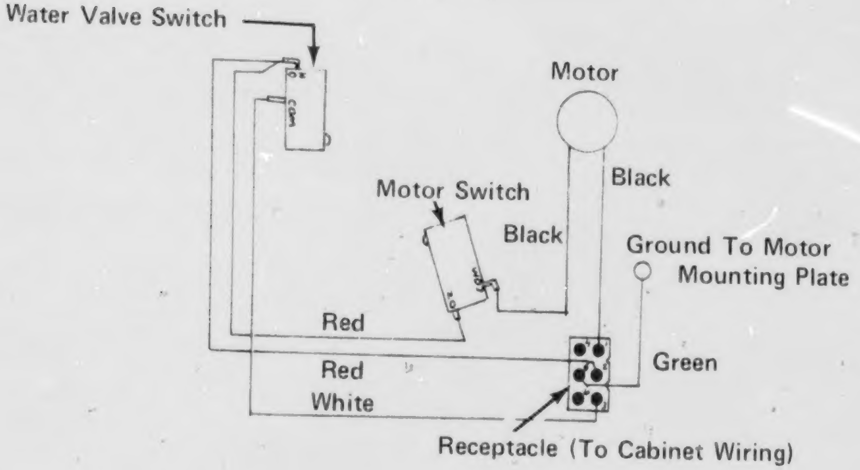

Brown
Blue
Black
Feeler
Arm
Switch
Orange
To Motor
Brown
Black
White
Blue
Safety Thermostat
(Black)
Operating Thermostat
Test Receptacles
(White)
Leaf Switch
Power Cord Plug
Mold Heater

Schematic

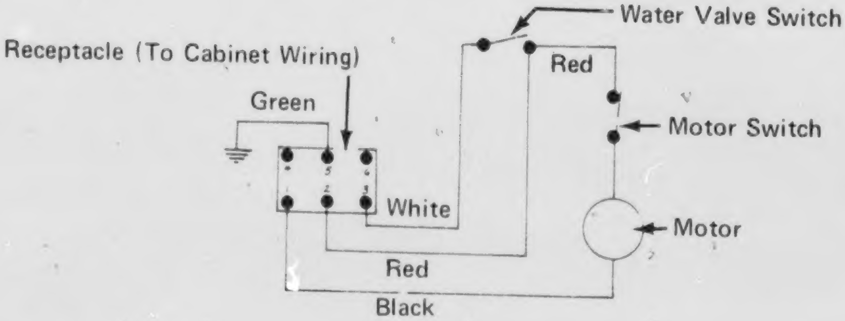

Brown
Orange
White
# 2 Switch
# 1 Switch
130 Ω
or
175 Ω
Brown
Blue
Black
Safety
Thermostat
Feeler Arm
Switch
Operating
Thermostat
Motor
Black
White
55 Ω
S. T. Test
Receptacle
O. T. Test
Receptacle
Mold Heater

Wiring Diagrams
Flex Tray Ice Maker

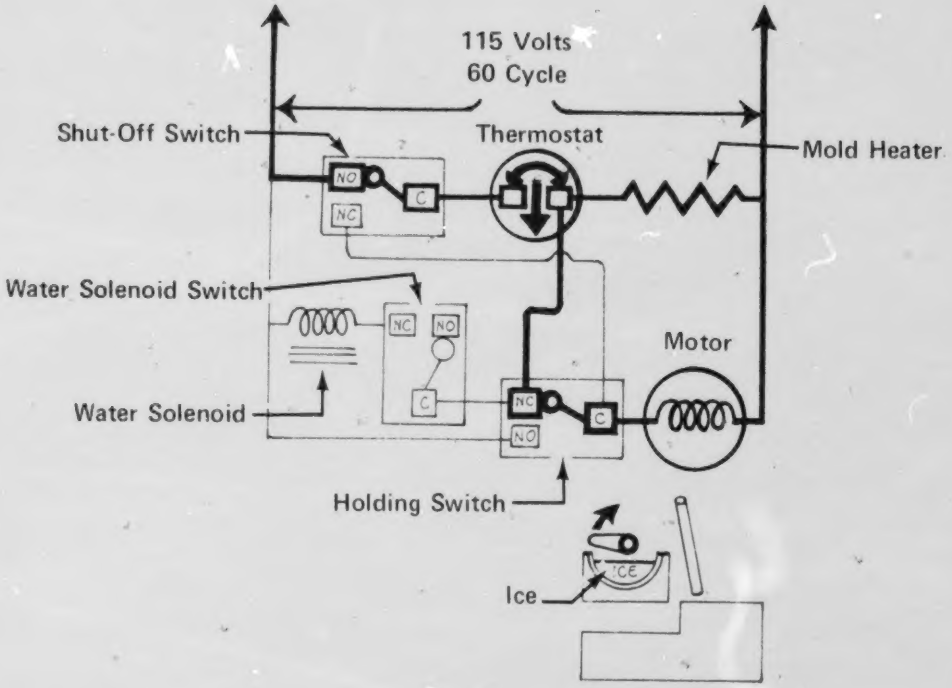
Pictoral


Water Valve Switch
Motor
Black
Motor Switch
Black
Ground To Motor Mounting Plate
Red
Red
Green
White
Receptacle (To Cabinet Wiring)

Schematic


Water Valve Switch
Receptacle (To Cabinet Wiring)
Red
Green
Motor Switch
White
Motor
Red
Black

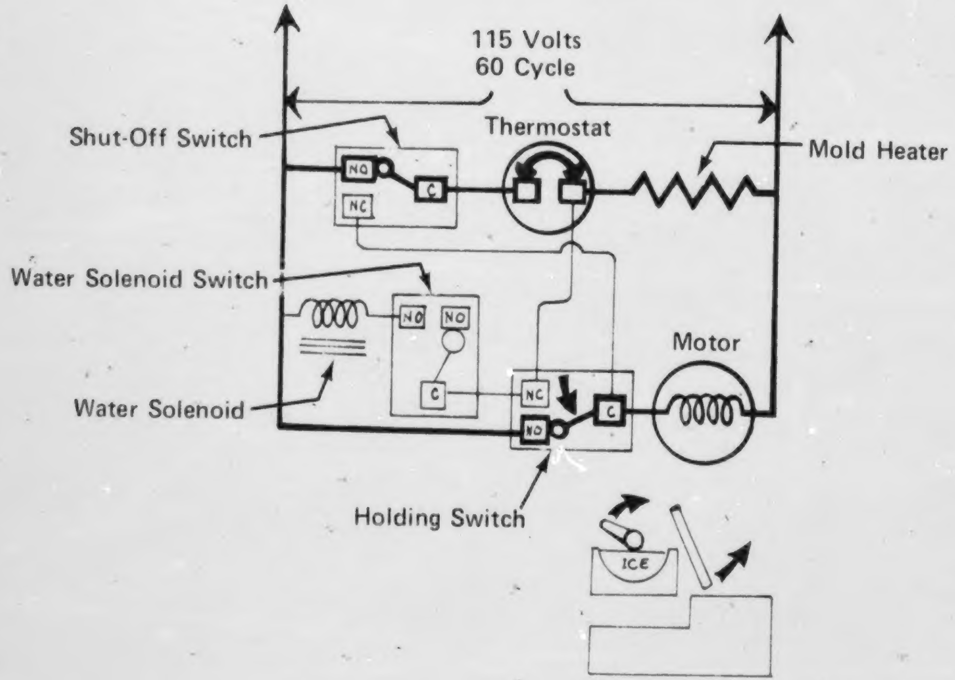
Crescent Shaped Cube Ice Maker


115 Volts
60 Cycle
Shut-Off Switch
Thermostat
Mold Heater
NO
NC
C
Water Solenoid Switch
NC
NO
C
Motor
Water Solenoid
NC
NO
C
Holding Switch
Ice
ICE

Circuit At Start Of Ejection Cycle

Crescent Shaped Cube Ice Maker

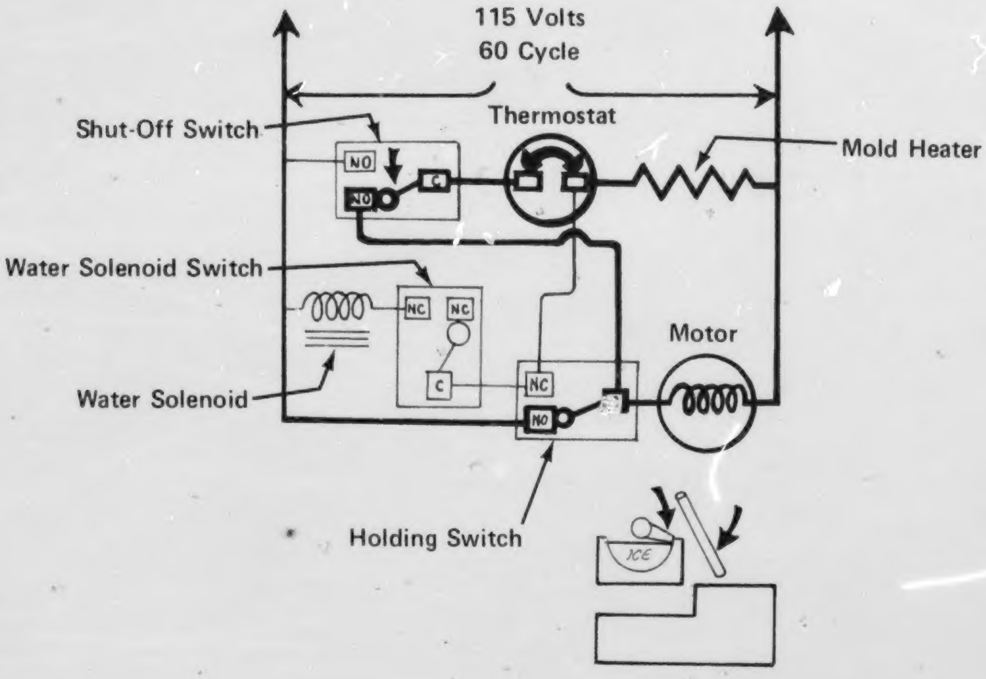
(Continued)


115 Volts
60 Cycle
Shut-Off Switch
Thermostat
Mold Heater
NO
NC
C
Water Solenoid Switch
NO
NO
C
Water Solenoid
Motor
NC
NO
C
Holding Switch
ICE

Circuit After Holding Switch Is Contacted By Cam

Crescent Shaped Cube Ice Maker

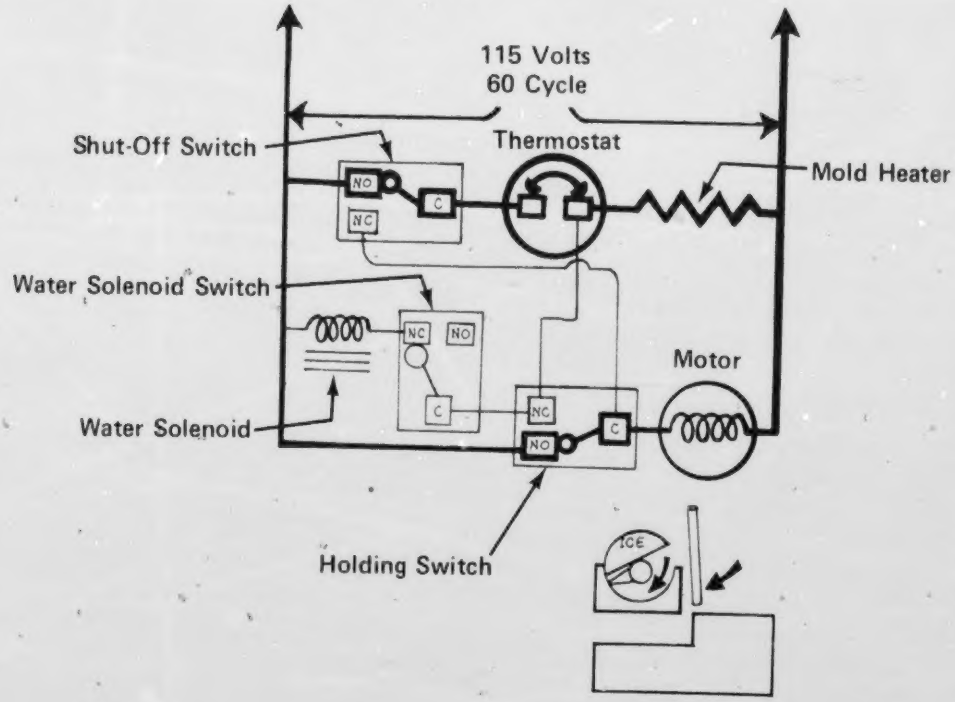
(Continued)


115 Volts
60 Cycle
Shut-Off Switch
Thermostat
Mold Heater
NO
NO
C
Water Solenoid Switch
NC
NC
C
Motor
Water Solenoid
NC
NO
Holding Switch
ICE

Circuit When Ejector Blades Contact Ice

Crescent Shaped Cube Ice Maker

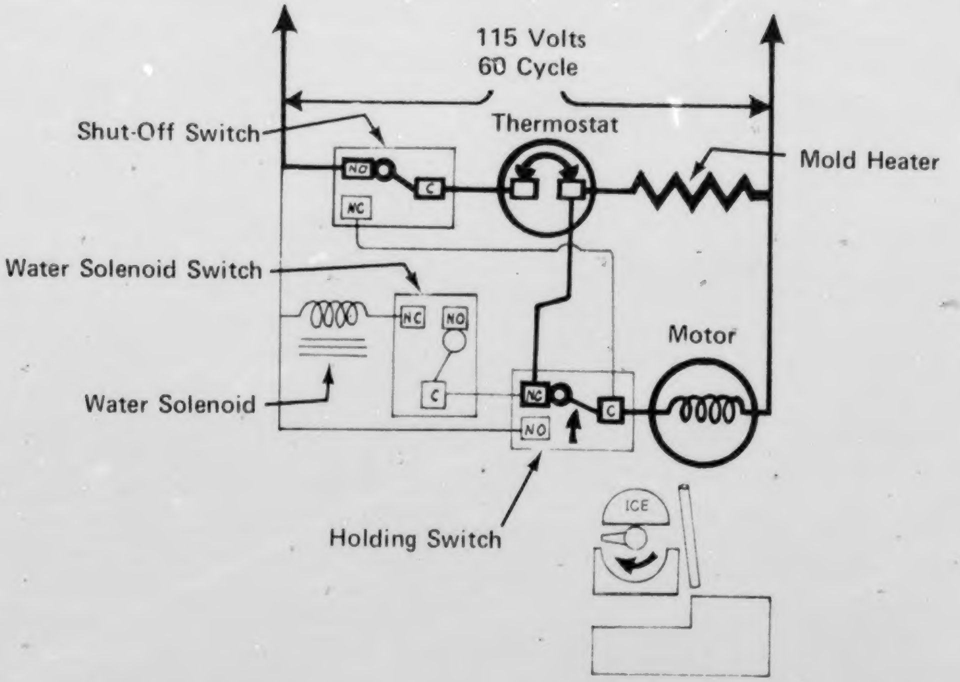
(Continued)


115 Volts
60 Cycle
Shut-Off Switch
Thermostat
Mold Heater
NO
NC
C
Water Solenoid Switch
NC
NO
C
Water Solenoid
Motor
NC
NO
C
Holding Switch
ICE

Circuit When Cam Closes Water Valve Switch

Crescent Shaped Cube Ice Maker

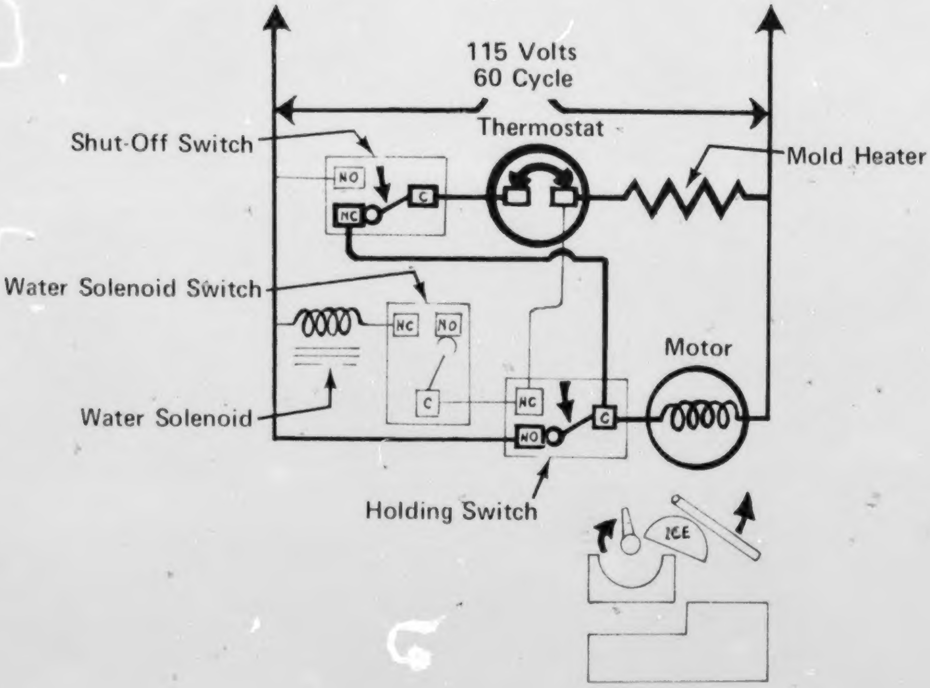
(Continued)


115 Volts
60 Cycle
Shut-Off Switch
Thermostat
Mold Heater
NO
NC
C
Water Solenoid Switch
Water Solenoid
Motor
Holding Switch
ICE

Circuit At End Of First Revolution

Crescent Shaped Cube Ice Maker

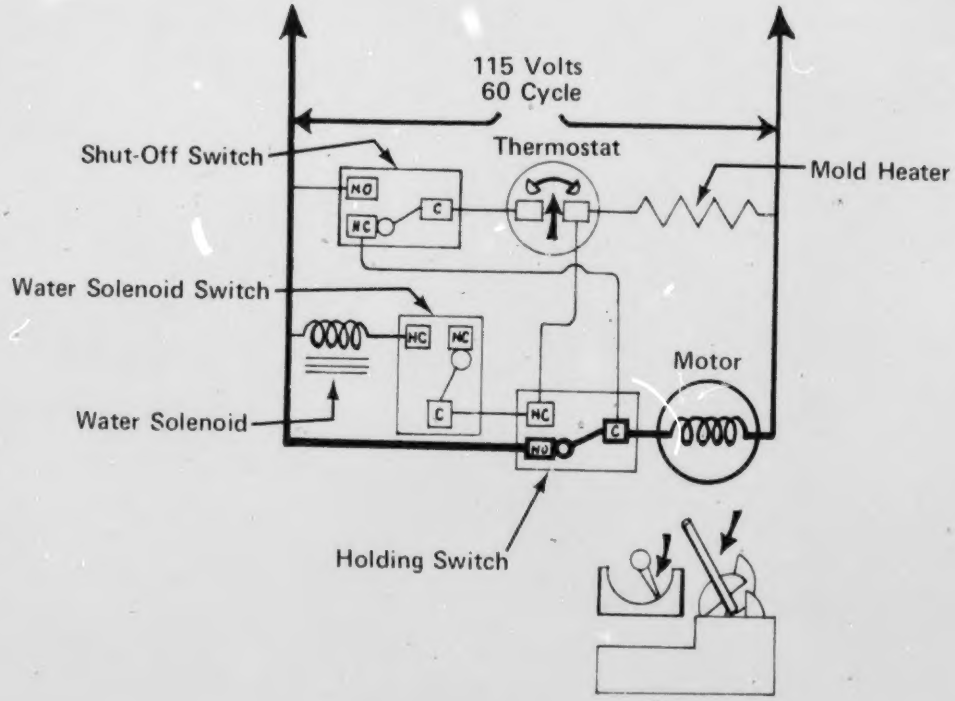
(Continued)


115 Volts
60 Cycle
Shut-Off Switch
Thermostat
Mold Heater
NO
NC
C
Water Solenoid Switch
NC
NO
C
Motor
Water Solenoid
NC
NO
C
Holding Switch
ICE

Circuit At Start Of Second Revolution

Crescent Shaped Cube Ice Maker

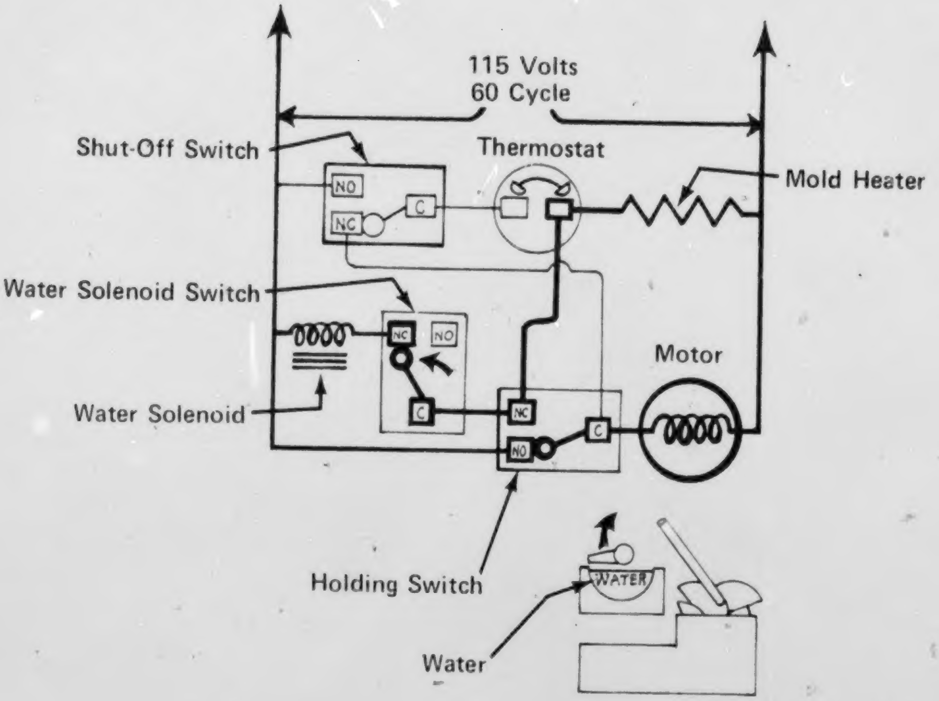
(Continued)


115 Volts
60 Cycle
Shut-Off Switch
Thermostat
Mold Heater
NO
NC
C
Water Solenoid Switch
NC
NC
C
Water Solenoid
Motor
NC
C
NO
Holding Switch

Circuit When Thermostat Opens

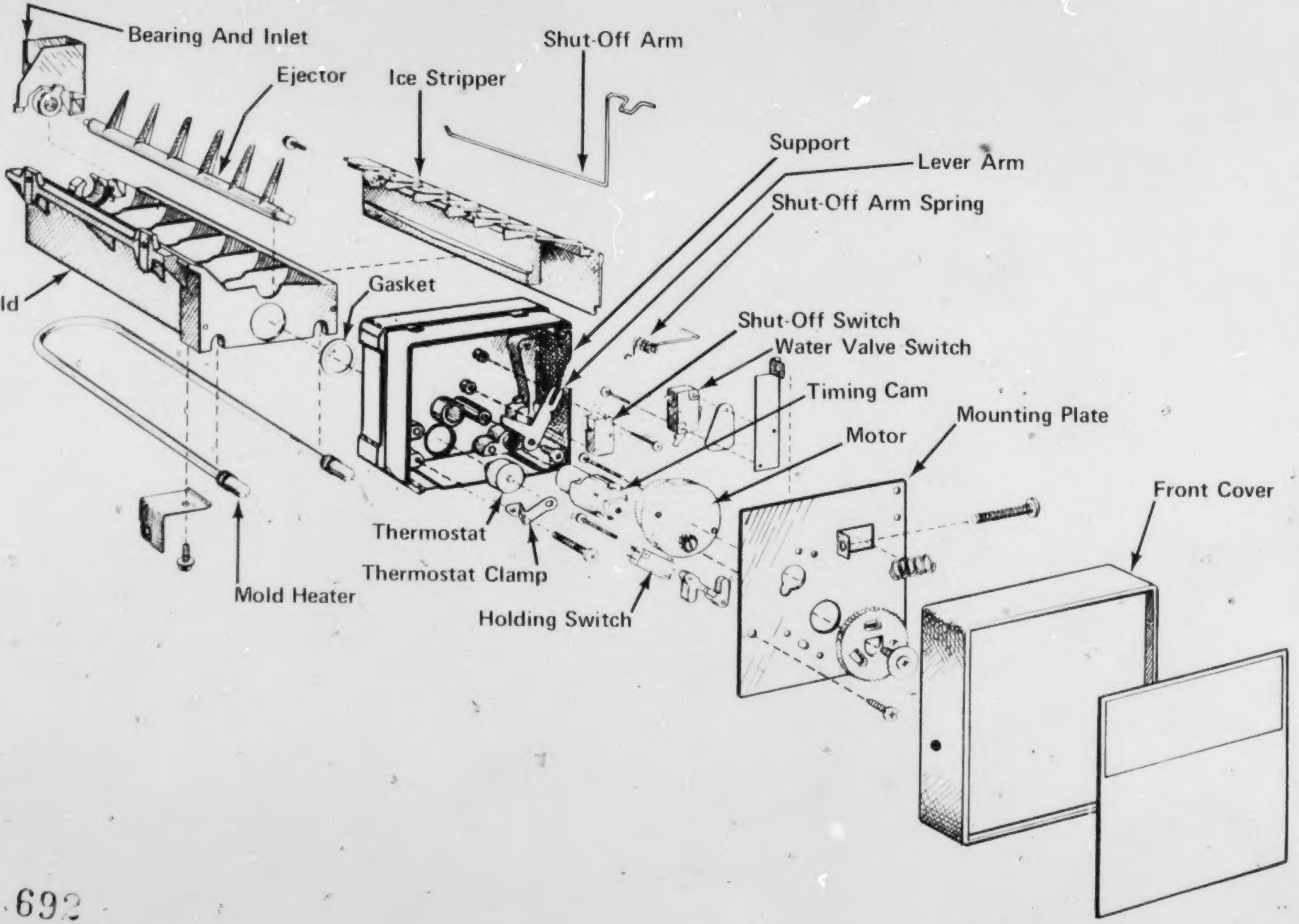
Crescent Shaped Cube Ice Maker

(Continued)

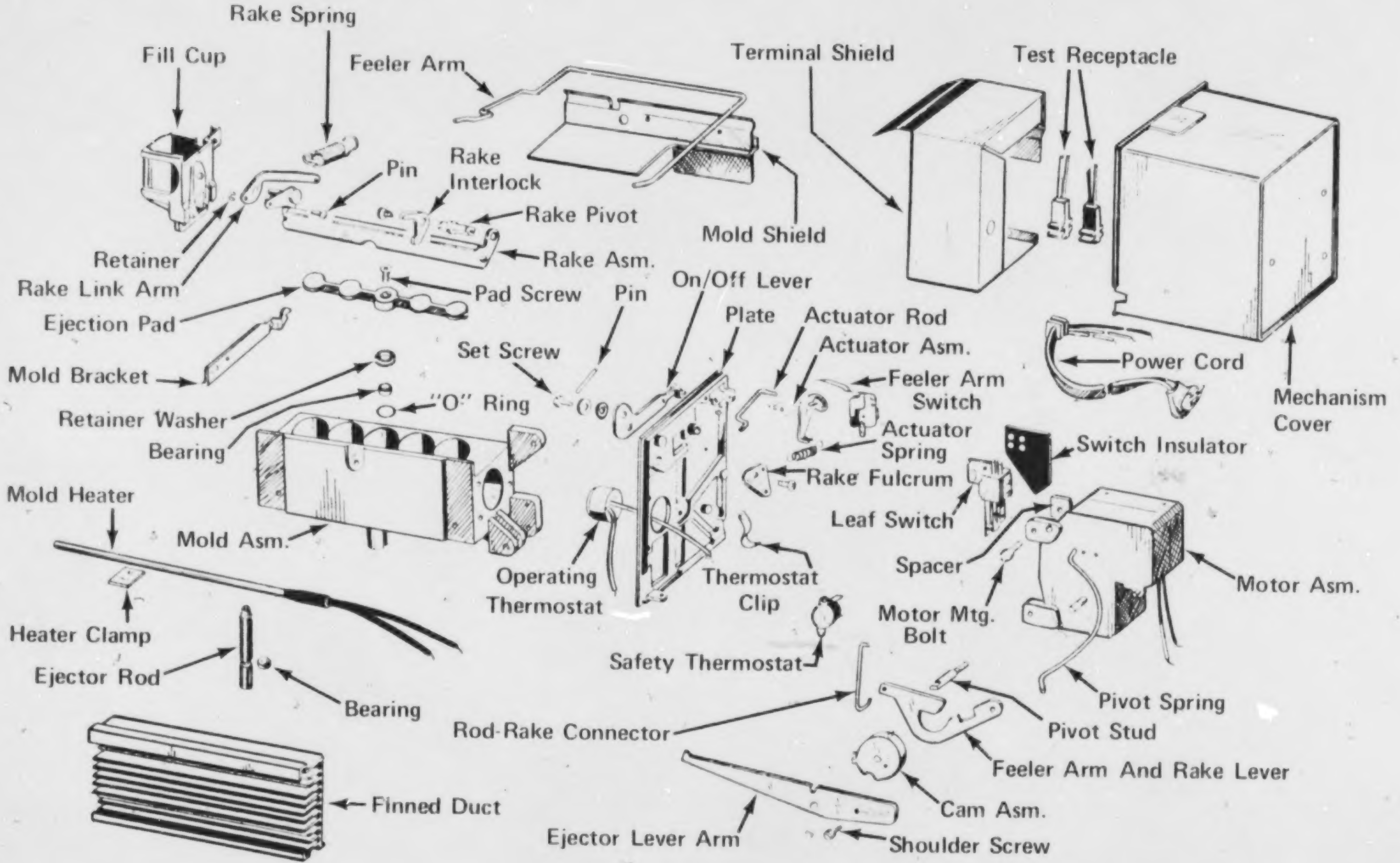

115 Volts
60 Cycle
Shut-Off Switch
NO
NC
C
Thermostat
Mold Heater
Water Solenoid Switch
NC
NO
C
Water Solenoid
Motor
NC
NO
C
Holding Switch
WATER
Water

Circuit During Water Fill

Parts Of The Crescent Shape Cube Ice Maker

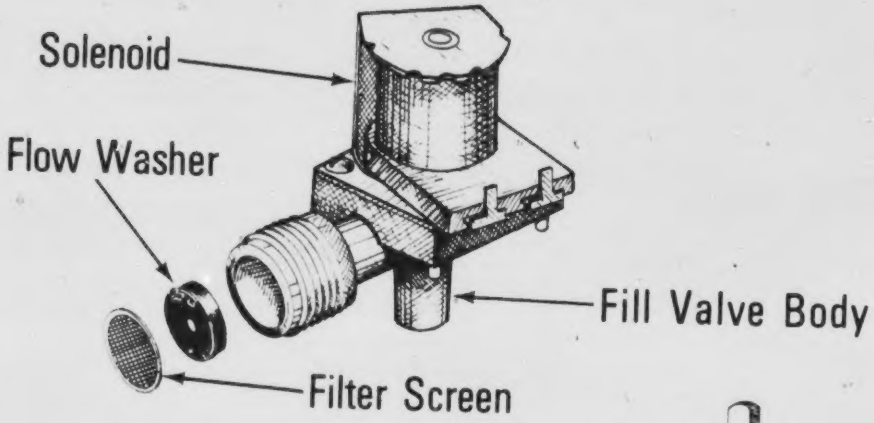

Bearing And Inlet
Shut-Off Arm
Ejector
Ice Stripper
Support
Lever Arm
Shut-Off Arm Spring
Mold
Gasket
Shut-Off Switch
Water Valve Switch
Timing Cam
Mounting Plate
Motor
Front Cover
Thermostat
Thermostat Clamp
Mold Heater
Holding Switch

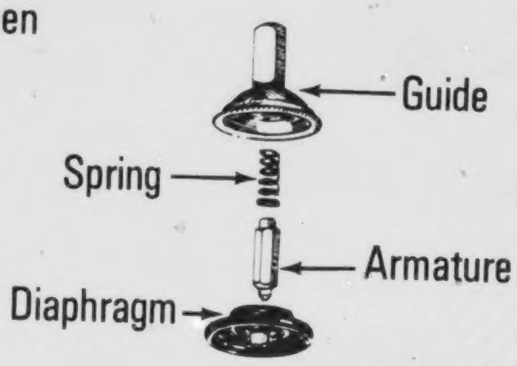
Parts Of The Five Cavity Ice Maker

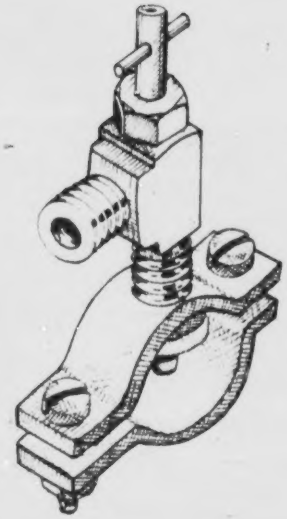

Rake Spring
Fill Cup
Feeler Arm
Terminal Shield
Test Receptacle
Pin
Rake Interlock
Rake Pivot
Mold Shield
Retainer
Rake Asm.
Rake Link Arm
Pad Screw
Pin
On/Off Lever
Ejection Pad
Plate
Actuator Rod
Actuator Asm.
Set Screw
Feeler Arm Switch
Power Cord
Mold Bracket
Mechanism Cover
"O" Ring
Retainer Washer
Actuator Spring
Switch Insulator
Bearing
Rake Fulcrum
Mold Heater
Leaf Switch
Mold Asm.
Spacer
Operating Thermostat
Thermostat Clip
Motor Asm.
Motor Mtg. Bolt
Heater Clamp
Safety Thermostat
Ejector Rod
Pivot Spring
Bearing
Pivot Stud
Rod-Rake Connector
Feeler Arm And Rake Lever
Finned Duct
Cam Asm.
Ejector Lever Arm
Shoulder Screw

Water Valves And Components

Fill Valve


Solenoid
Flow Washer
Fill Valve Body
Filter Screen


Guide
Spring
Armature
Diaphragm



Saddle
Valve

DOMESTIC REFRIGERATOR ICE MAKERS
UNIT VI

JOB SHEET #1--INSTALL A REFRIGERATOR EQUIPPED WITH AN ICE MAKER

I. Tools and materials

   A. Refrigerator equipped with an ice maker

   B. Roll of 1/4" o.d. copper tubing

   C. Water line saddle valve

   D. Two open end wrenches

   E. 3/8" drill motor

   F. 5/32" and 3/8" drill bit

   G. Standard slot type screwdriver

   H. Slip groove pliers

   I. Tubing cutter

II. Procedure

   A. Place refrigerator in proper location

   B. Level ice maker

   C. Locate cold water supply line

   (NOTE: This line is often most accessible underneath the kitchen sink.)

   D. Shut off water

   E. Open a faucet to drain water line

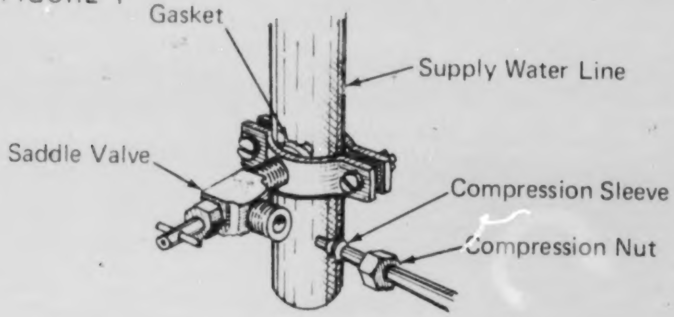
   F. Drill a 5/32" hole in water line

   (NOTE: Some saddle valves are self-tapping when placed on a copper water line.)

JOB SHEET #1

G. Place saddle valve on water line (Figure 1)

FIGURE 1


Gasket
Supply Water Line
Saddle Valve
Compression Sleeve
Compression Nut

H. Be sure that the inlet of valve is securely in hole in water line

I. Check to see that the gasket is in place

J. Measure distance from water supply to water fill valve

K. Add an additional four feet of tubing to be looped behind the refrigerator

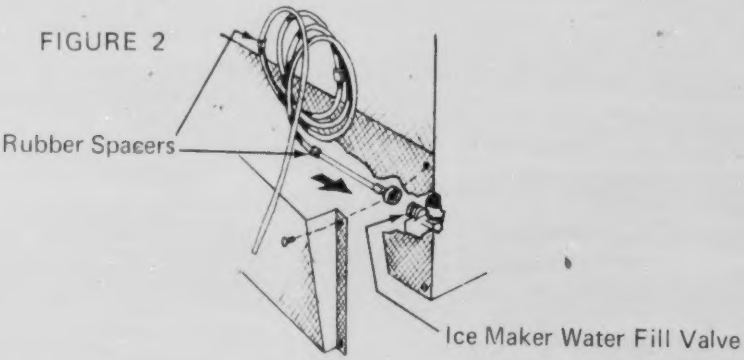
(NOTE: If the tubing is to be run through the bottom of the kitchen cabinets drill a 3/8" hole for the tubing to go through.)

L. Connect tubing to saddle valve

M. Make three or four loops in tubing behind refrigerator (Figure 2)

(NOTE: The loops in the tubing allow the refrigerator to be moved out for cleaning or repair.)

FIGURE 2


Rubber Spacers
Ice Maker Water Fill Valve

JOB SHEET #1

N. Close valve stem on saddle valve

O. Turn on main water supply

P. Close faucet that was opened to drain water line

Q. Place a container at the end of the water line

R. Open valve stem on saddle

S. Allow a small amount of water to run through the line to flush it

T. Close valve stem on saddle valve

U. Remove any panels that may be necessary to gain entrance to water fill valve

V. Connect water line to fill valve

W. Turn on saddle valve

X. Check for water leaks

Y. Replace any panels that were removed

Z. Have instructor check installation

AA. Clean up and put away tools and materials

DOMESTIC REFRIGERATOR ICE MAKERS
UNIT VI

JOB SHEET #2--DISASSEMBLE AND CLEAN A WATER FILL VALVE

I. Tools and materials

A. Fill valve

B. Phillips screwdriver

C. Standard slot type screwdriver

D. Pocket screwdriver

II. Procedure

A. Use a pocket screwdriver to remove filter screen and flow washer

B. Remove solenoid

C. Remove plate from top of valve

D. Remove guide, spring, armature and diaphragm

(NOTE: The diaphragm may be slightly stuck to the body of the valve. Do not use a sharp object to pry loose, because this may damage it.)

E. Wash the body, diaphragm, armature, filter screen and flow washer under running water

F. Hold the diaphragm up to the light to be sure that the two small holes at the sides of the diaphragm are clear

G. Reassemble valve

(CAUTION: Be sure that the diaphragm fits down into the groove in the valve body. If it does not fit properly water will flood the ice compartment.)

H. Have instructor check

I. Clean up and put away tools and materials

DOMESTIC REFRIGERATOR ICE MAKERS
UNIT VI

JOB SHEET #3--REPLACE THERMOSTAT IN A CRESCENT SHAPED CUBE ICE MAKER

I. Tools and materials

- A. Crescent shaped cube ice maker
- B. Standard slot type screwdriver
- C. Phillips screwdriver
- D. Side cutters
- E. Wire connectors
- F. Alumilastic

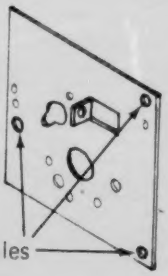
II. Procedure

(NOTE: Ice maker should be out of the refrigerator while this procedure is being done.)

- A. Remove front cover
- B. Remove the screws that hold the mounting plate (Figure 1)

  (NOTE: There are only three screws to remove as shown in Figure 1. Do not remove anything else from the mounting plate.)

FIGURE 1



- C. Move mounting plate and attached components out of the way
- D. Cut thermostat wires
- E. Remove screw from thermostat clamp
- F. Remove thermostat

JOB SHEET #3

G. Clean off old alumilastic from ice maker mold

H. Put alumilastic on new thermostat

I. Place thermostat in position

J. Replace thermostat clamp and screw

K. Connect thermostat wires

L. Have instructor check

M. Replace mounting plate

N. Replace front cover

O. Clean up and put away tools and materials

DOMESTIC REFRIGERATOR ICE MAKERS
UNIT VI

JOB SHEET #4--REPLACE MOLD SEAL, BEARING, AND RETAINER IN FIVE CAVITY ICE MAKER

I. Tools and materials

A. Five cavity ice maker

B. Seal remover (Robinair #14368)

C. Retainer washer installation tool (Robinair #14173)

D. Standard slot type screwdriver

E. Phillips screwdriver

F. Seal assembly

G. Retainer remover

H. Silicon lubricant

I. 9/16" box end wrench

J. 1/4" nutdriver

II. Procedure

(NOTE: Ice maker should be removed from the refrigerator when this procedure is being performed.)

A. Remove mechanism cover

(NOTE: This cover is held on with two plastic plugs, one at the top and one at the bottom.)

B. Remove terminal shield

C. Remove ejection pad screw

D. Rotate cam until the shoulder screw is at the 12 o'clock position

E. Remove shoulder screw

F. Remove pivot stud

G. Remove ejector lever arm from ejector rod

H. Remove ejection pad

I. Slide ejector rod out of the bottom of the mold

JOB SHEET #4

J. Remove metal retainer washer from mold

(NOTE: In order to remove this washer without damaging the mold, a special tool is needed which is available from Robinair #14368)

K. Remove bearing and seal

L. Clean the recess in the mold and inspect

M. Apply a small amount of silicon lubricant to bearing and seal recesses

N. Apply a small amount of silicon lubricant to shaft hole in mold, new bearing, seal and the shaft of the installation tool

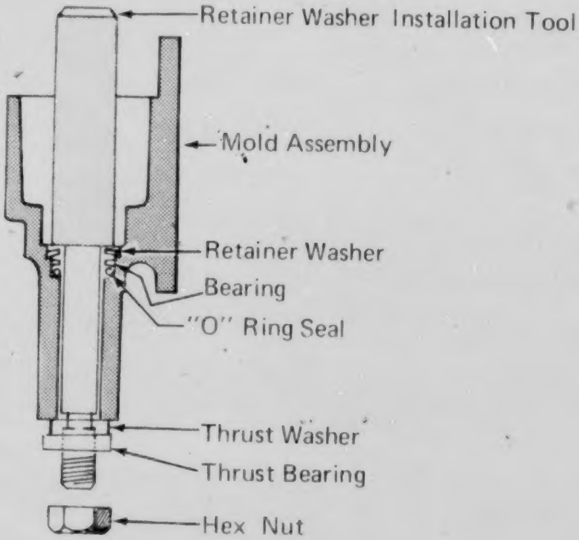
O. Place retainer washer, bearing, and seal on installer

(NOTE: The retainer washer should be placed on the installer with the "crowned" side against the shoulder of the tool.)

P. Insert tool in mold and position the retainer washer in mold recess

Q. Place thrust washer, thrust bearing and hex nut on installation tool (Figure 1)

FIGURE 1


Retainer Washer Installation Tool
Mold Assembly
Retainer Washer
Bearing
"O" Ring Seal
Thrust Washer
Thrust Bearing
Hex Nut

R. Seat retainer by tightening hex nut

JOB SHEET #4

S. Remove installer and inspect retainer washer

(NOTE: If the retainer is properly seated the washer will be flattened.)

T. Inspect ejector rod for rough spots

U. Install a new bearing on ejector rod

V. Place a small amount of silicon lubricant on ejector rod

W. Insert ejector rod from bottom of mold

X. Put ejector rod all of the way down

Y. Place ejector pad in bottom of mold

Z. Check clearance between pad and side of mold

(NOTE: If the pad touches the side of the mold, remove the pad, rotate it 180° and place it back in the bottom of mold and check for fit.)

AA. Tighten screw in the center of the pad

BB. Move rod up and down to check that pad doesn't bind on mold

CC. Insert ejector lever in slot of ejector rod

DD. Replace pivot stud

EE. Replace shoulder screw

FF. Replace terminal shield

GG. Replace mechanism cover

HH. Fill mold with water and check for leaks around ejector rod

II. Have instructor check

JJ. Clean up and put away tools and materials

DOMESTIC REFRIGERATOR ICE MAKERS
UNIT VI

JOB SHEET #5--ADJUST WATER VALVE SWITCH IN A FLEX TRAY ICE MAKER

I. Tools and materials

   A. Flex tray ice maker in refrigerator

   B. Standard slot type screwdriver

   C. Container graduated in CC's, such as baby bottle or medicine bottle

II. Procedure

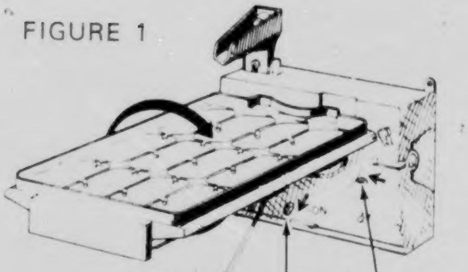
   A. Manually start ice making cycle (Figure 1)

      1. Push tray lock lever towards tray

      2. Turn tray clockwise until gears engage

      3. Cycle will continue once started

FIGURE 1



Switch Actuator Must Be Down For Motor To Operate

Push Toward Tray Shaft To Unlock Tray

   B. Hold the container under fill spout

   C. Catch the water as it is dispensed towards the end of the cycle

   D. Check container; it should have 200 cc's of water in it

   E. Remove plug on right hand side of ice maker

   F. Insert screwdriver into adjusting screw slot

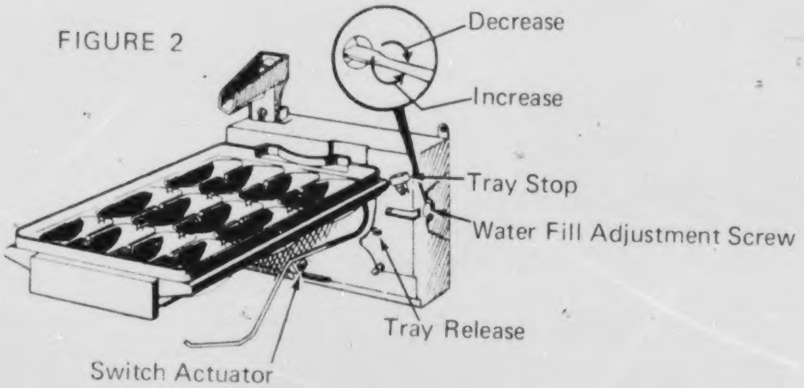
JOB SHEET #5

G. Turn adjusting screw--one complete revolution changes the water supply 20 cc's (Figure 2)

1. Clockwise decreases

2. Counter-clockwise increases

FIGURE 2


Decrease
Increase
Tray Stop
Water Fill Adjustment Screw
Tray Release
Switch Actuator

H. Have instructor check

I. Clean up and put away tools and materials

DOMESTIC REFRIGERATOR ICE MAKERS
UNIT VI

JOB SHEET #6--REPLACE MOLD HEATER IN A CRESCENT SHAPED CUBE ICE MAKER

I. Tools and materials

A. Crescent shaped cube ice maker

B. Mold heater

C. Standard slot type screwdriver

D. Phillips screwdriver

E. Side cutters

II. Procedure

A. Remove ice maker from refrigerator

B. Allow ice maker to warm-up to room temperature and then remove cover

(NOTE: If the ice maker is not at room temperature some of the plastic parts may be damaged when attempting to remove them.)

C. Remove ice stripper from side of mold

D. Remove the three screws that hold the mounting plate

E. Move mounting plate and components out of the way

F. Remove thermostat from mold

G. Cut mold heater wires

H. Remove the four bolts that hold the mold to the support housing

I. Remove mold from support housing

(NOTE: Be careful not to destroy the thermostat gasket.)

J. Pry the old mold heater out the bottom of the mold

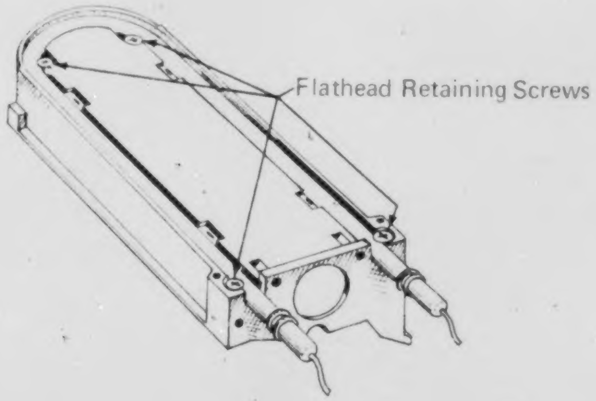
K. Clean the old alumilastic from the mold groove

JOB SHEET #6

L. Install new heater using retainer screws (Figure 1)

(NOTE: Replacement heaters are secured with screws which are included with the heater kit. The holes for the screws are drilled there at the factory.)

FIGURE 1



M. Clean old alumilastic from mold thermostat recess and from thermostat

N. Connect mold to support housing

(NOTE: Be careful not to damage the thermostat gasket.)

O. Put new alumilastic on thermostat

P. Install thermostat and clamp

Q. Connect new heater wires

R. Replace mounting plate

S. Tighten mounting plate screws

T. Replace ice stripper

U. Have instructor check

V. Replace ice maker in refrigerator

W. Manually start ice maker into cycle

X. Clean up and put away tools and materials

DOMESTIC REFRIGERATOR ICE MAKERS
UNIT VI

NAME ______________________

TEST

1. Match the terms on the right to the correct definitions or descriptions.

_____a. Depositing ice into the storage bin

_____b. Eccentric shaped rotating shaft which operates another mechanism such as a plunger or switch arm

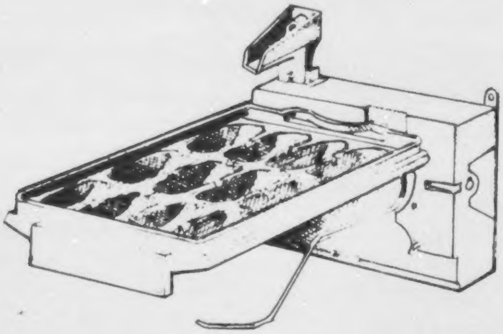
_____c. The component part of most ice makers in which the ice is frozen

_____d. Part on the edge of the crescent shaped cube ice maker mold which prevents the cubes from becoming lodged during harvest

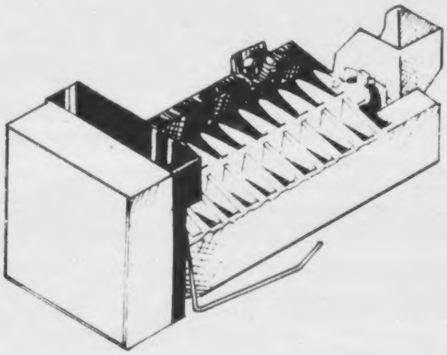
_____e. A half moon shaped object

1. Cam
2. Crescent shape
3. Harvest
4. Ice stripper
5. Mold

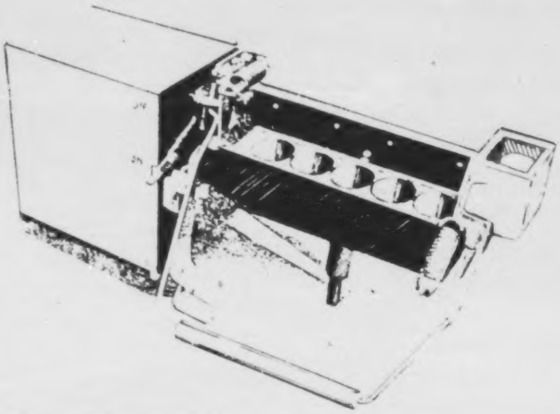
2. Identify three types of ice makers.



a. ______________________

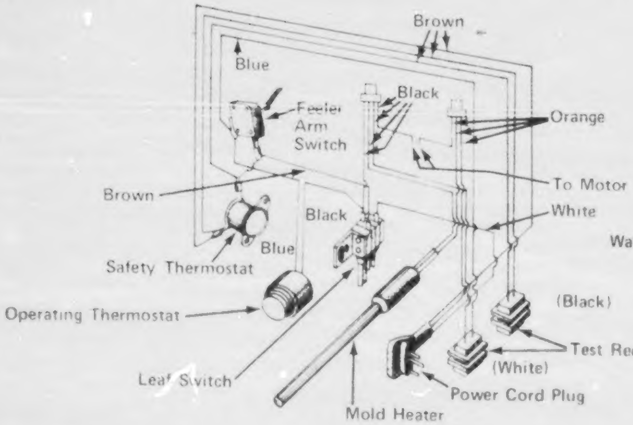


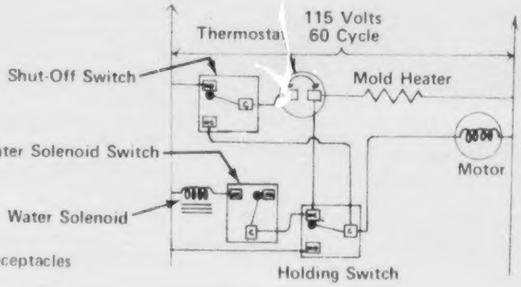
b. ______________________



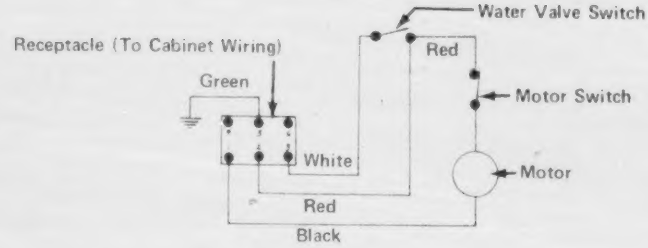
c. ______________________

3. Identify the pictorial and schematic wiring diagrams for each of the three types of ice makers.

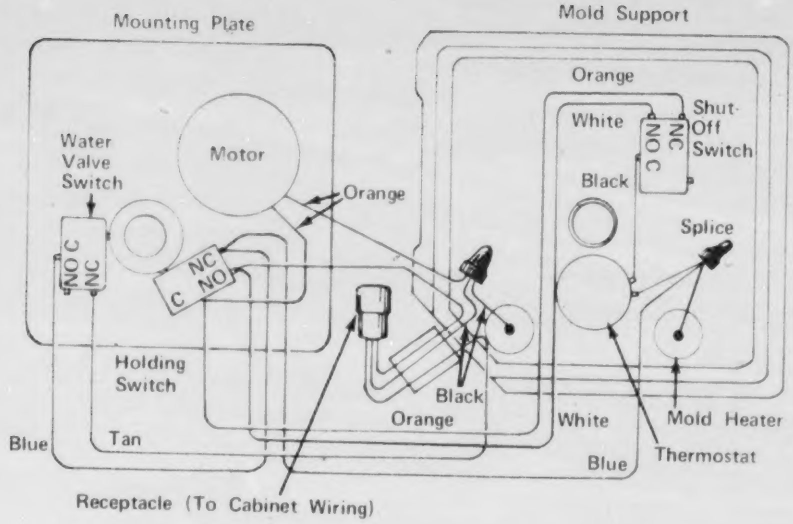

Brown
Blue
Feeler Arm Switch
Black
Orange
To Motor
White
Brown
Black
Blue
Safety Thermostat
Operating Thermostat
(Black)
Test Receptacles
(White)
Leaf Switch
Power Cord Plug
Mold Heater


115 Volts
60 Cycle
Thermostat
Shut-Off Switch
Mold Heater
Motor
Water Solenoid Switch
Water Solenoid
Holding Switch

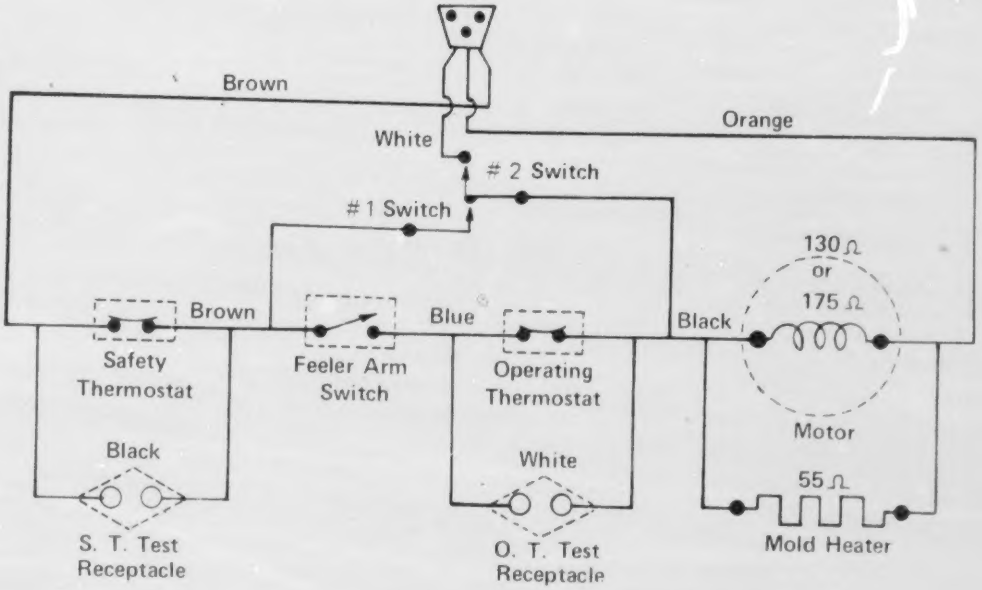
a. ______________________ b. ______________________


Water Valve Switch
Receptacle (To Cabinet Wiring)
Red
Green
Motor Switch
White
Motor
Red
Black

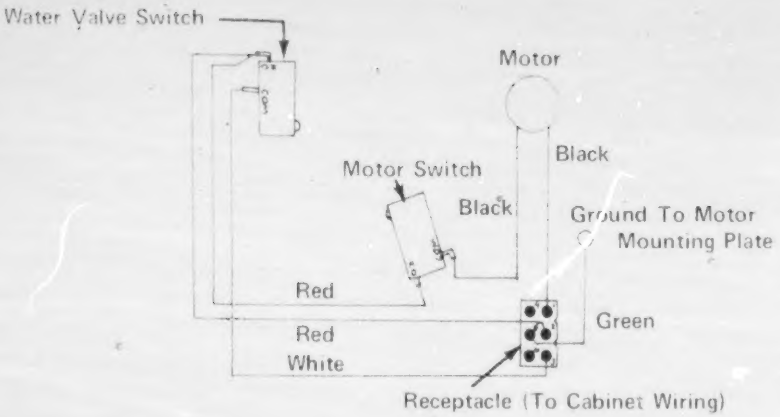
c. ______________________


Mounting Plate
Mold Support
Orange
White
Shut-Off Switch
NC
NO C
Water Valve Switch
Motor
Orange
Black
Splice
NO C
NC
NC
C NO
Holding Switch
Black
Orange
White
Mold Heater
Blue
Tan
Blue
Thermostat
Receptacle (To Cabinet Wiring)

d. ______________________


Brown
White
Orange
# 2 Switch
# 1 Switch
130 Ω
or
175 Ω
Brown
Blue
Black
Safety Thermostat
Feeler Arm Switch
Operating Thermostat
Motor
Black
White
55 Ω
S. T. Test Receptacle
O. T. Test Receptacle
Mold Heater

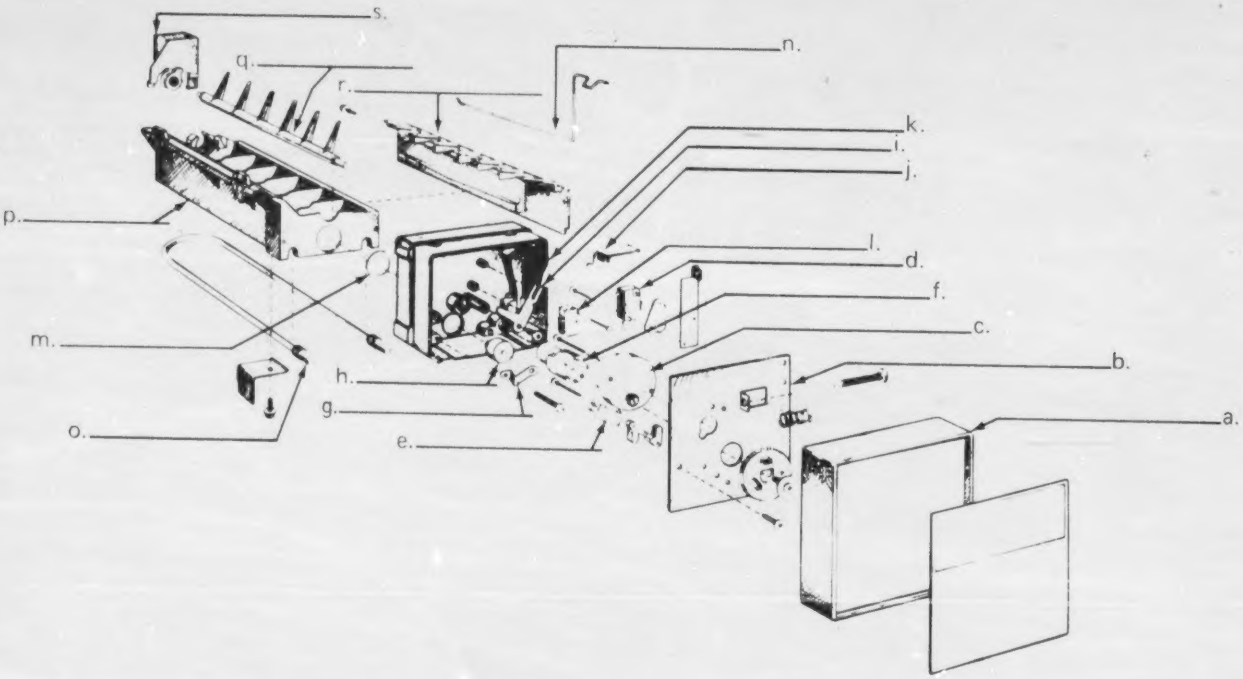
e. ______________________


Water Valve Switch
Motor
Black
Motor Switch
Black
Ground To Motor Mounting Plate
Red
Green
Red
White
Receptacle (To Cabinet Wiring)

f. ______________________

4. Discuss the operation of the crescent shaped cube ice maker.

5. Identify the parts of the crescent shaped cube ice maker.



6. Match the problems of the crescent shaped cube ice maker on the left to the remedy or check on the right.

______a. 1) Ejector blades stopped at 10 o'clock position
  - a) Check holding switch
  - b) Switch plunger depressed
  - c) Should have continuity between "C" and "NO"
  - d) Replace switch if open

2) Ejector blades stopped at 12 o'clock position
  - a) Check shut-off switch
  - b) Should have continuity between "C" and "NC"
  - c) Replace if open

3) Ejector blades stopped at 4 o'clock position
  - a) Check heater and thermostat for continuity
  - b) Replace the open component

1. Undersized ice cubes
2. Water fails to enter mold
3. Ice maker won't start
4. Ice maker fails to complete cycle
5. Water spills from mold

_____b. 1) Lower shut-off arm to lowest position
2) Check for voltage to ice maker
3) Check freezer temperature; should be 10°F or less
4) Start motor manually
5) If motor runs after manual start, check:
   a) Thermostat for continuity
   b) Continuity "C" to "NC" of holding switch
   c) Continuity "C" to "NO" on shut-off switch
   d) Operation of motor with test cord

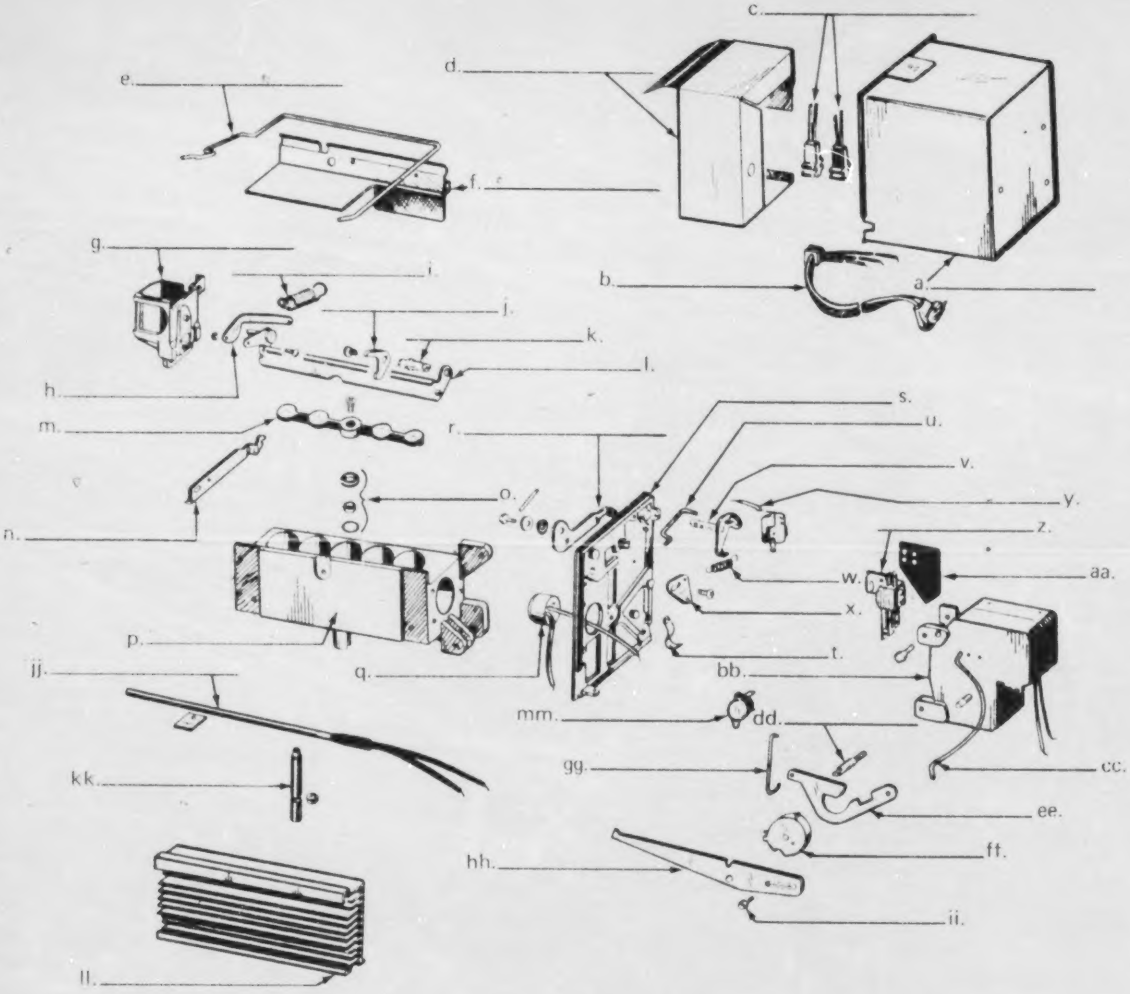
_____c. 1) Check mold for level
2) Check screen in water valve
3) Adjust water valve switch
4) Check bond between thermostat and mold
5) Check for corrosion at saddle valve

_____d. 1) Check freezer temperature
2) Check water supply components
3) Check fill tube for ice blockage
   a) Check water valve for seepage
   b) Check fill tube heater for continuity
4) Check water valve solenoid for continuity
5) With the plunger out on the water valve switch, check for continuity between "C" and "NC"

_____e. 1) Check mold for level
2) Check for leak between fill tube and water inlet
3) Check water valve for leaking water through valve when not energized
4) Adjust water switch

7. Discuss the operation of the five cavity ice maker.

8. Identify the parts of the five cavity ice maker.


c.
d.
e.
f.
g.
i.
j.
k.
l.
b.
a.
h.
s.
u.
m.
r.
v.
y.
o.
z.
n.
w.
aa.
x.
p.
t.
q.
bb.
jj.
mm.
dd.
gg.
cc.
ee.
kk.
ff.
hh.
ii.
ll.

9. Match the problem of the five cavity ice maker on the left to the remedy or check on the right.

______a.
1) Leaky water valve
2) Cubes not ejecting properly
3) Water fill time too long
4) Fill tube out of place
5) Leaking ejector rod seal
6) Ice maker not level
7) Thermostat stuck closed
8) Leaf switch contacts stuck closed

______b.
1) Water fill time too short
2) Low water pressure
3) Partially restricted water valve screen
4) Check for corrosion at saddle valve

______c.
1) Feeler arm broken
2) Feeler arm switch defective or out of adjustment

______d.
1) No source voltage to ice maker
2) Manual switch turned off
3) Check for adequate water supply
4) Feeler arm not down
5) Feeler arm switch defective or out of adjustment
6) Safety thermostat open
7) Operating thermostat open--check freezer temperature
8) Leaf switch broken or out of adjustment
9) Defective water valve solenoid
10) Defective motor

______e.
1) Stuck ejector rod
2) Broken shoulder screw
3) Broken rake assembly

______f.
1) Defective water valve solenoid
2) Bent leaf switch
3) Restricted water supply
4) Plugged water valve screen
5) Ice in fill tube
6) Loose or broken wire

1. Makes too much ice
2. Will not eject cubes
3. Not making ice
4. Will not fill with water
5. Cubes too small
6. Water overfills

10. Discuss the operation of the flex tray ice maker.

11. Match the problems of the flex tray ice maker on the left to the remedies and checks on the right.

______ a.
1) Check for restriction in water line and valve filter-screen
2) Check for ice in fill tube
3) Check water valve solenoid for open circuit
4) Check water valve switch
5) Check wiring and connector plug

______ b.
1) Check mold for level
2) Check for restrictions in water supply
3) Adjust water fill switch
4) Check for corrosion at saddle valve

______ c.
1) Check mold for level
2) Check placement of water fill tube
3) Check for leaky water valve
4) Adjust water fill switch
5) Cubes not being ejected

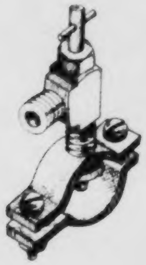
______ d.
1) Check actuator sensor arm
2) Check for pin of switch actuator to be in groove of final stage timing gear

______ e.
1) Freezer temperature control set to high
2) Defective sensing element
3) Broken sensing element spring
4) Broken spring on motor switch actuator

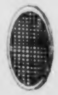
______ f.
1) Check freezer temperature; should be 15°F or less
2) Check position of sensor arm
3) Defective sensing element
4) Defective motor control switch
5) Check wiring and connector plug

1. Water spills from mold
2. Makes too much ice
3. Ice maker will not start
4. Water fails to enter ice tray
5. Undersized ice cubes
6. Cubes stuck together in storage bin

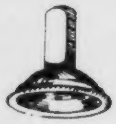
12. Identify the water valves and components.



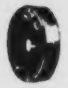
a. ____________

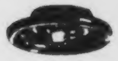


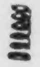
b. ____________

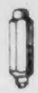


c. ____________

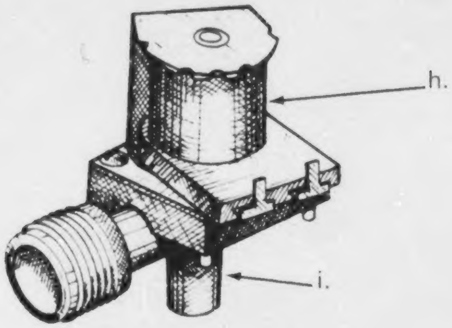








d. __________ e. __________ f. __________ g. __________



h. ____________________ i. ____________________

13. Demonstrate the ability to:

   a. Install a refrigerator equipped with an ice maker.

   b. Disassemble and clean a water fill valve.

   c. Replace thermostat in a crescent shaped cube ice maker.

   d. Replace mold seal, bearing, and retainer in five cavity ice maker.

   e. Adjust water valve switch in a flex tray ice maker.

   f. Replace mold heater in a crescent shaped cube ice maker.

(NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

DOMESTIC REFRIGERATOR ICE MAKERS
UNIT VI

ANSWERS TO TEST

1. a. 3

   b. 1

   c. 5

   d. 4

   e. 2

2. a. Flex tray ice maker

   b. Crescent shaped cube ice maker

   c. Five cavity ice maker

3. a. Pictorial, five cavity ice maker

   b. Schematic, crescent shaped cube ice maker

   c. Schematic, flex tray ice maker

   d. Pictorial, crescent shaped cube ice maker

   e. Schematic, five cavity ice maker

   f. Pictorial, flex tray ice maker

4. a. Water enters ice maker

   b. Water freezes in mold

   C. Ice maker thermostat closes at 18°F

   d. Circuit is completed to motor and mold heater

   e. Motor starts, turning timing cam and ejector blades

   f. Timing cam moves holding switch to normally open position

   g. Ejector blades reach the ice and apply pressure

   h. Timing cam raises and lowers the shut-off arm and switches the shut-off switch to normally closed

   i. Ice is loosened by the mold heater and is scooped out by ejector blades

j. Timing cam closes water valve switch

k. First revolution ends with ice resting on blades

l. Thermostat remains closed

m. Timing cam actuates holding switch to normally closed position

n. Second revolution begins

o. Timing cam again moves holding switch to the normally open position

p. Shut-off arm raises and lowers switching shut-off switch to normally closed position

q. Ice is dumped into storage bin

r. Ice maker thermostat opens--50°F

s. Mold heater is disconnected

t. Timing cam closes water valve switch

u. Water valve solenoid is energized

v. Water enters the ice maker mold

w. Timing cam actuates holding switch to normally closed position

5. a. Front cover

b. Mounting plate

c. Motor

d. Water valve switch

e. Holding switch

f. Timing cam

g. Thermostat clamp

h. Thermostat

i. Lever arm

j. Shut-off arm spring

k. Support

l. Shut-off switch

m. Gasket

n. Shut-off arm

o. Mold heater

p. Mold

q. Ejector

r. Ice stripper

s. Water inlet

6. a. 4

b. 3

c. 1

d. 2

e. 5

7. Discussion should include:

a. Water enters ice maker

b. Water freezes in the mold

c. Ice maker thermostat closes at 16°F

d. Leaf switch contacts are open during freezing

e. Thermostat closing completes circuit to motor and mold heater

f. Motor stalls until the ice is loosened by the heater

g. Cam rotates closing leaf switch #1

h. Cubes are raised from the mold

i. Cubes are swept into the bin by the rake assembly

j. Cam rotates closing leaf switch #2

k. After approximately six seconds switch #2 opens

l. The actuator leaf falls into open area on the cam terminating the cycle

8. a. Mechanism cover
   b. Power cord
   c. Test receptacles
   d. Terminal shield
   e. Feeler arm
   f. Mold shield
   g. Fill cup
   h. Rake link arm
   i. Rake spring
   j. Rake interlock
   k. Rake pivot
   l. Rake assembly
   m. Ejection pad
   n. Mold bracket
   o. Seal assembly
   p. Mold assembly
   q. Operating thermostat
   r. On/Off lever
   s. Plate
   t. Thermostat clip
   u. Actuator rod
   v. Actuator assembly
   w. Actuator spring
   x. Rake fulcrum
   y. Feeler arm switch
   z. Leaf switch
   aa. Switch insulator

bb. Motor assembly

cc. Pivot spring

dd. Pivot stud

ee. Feeler arm and rake lever

ff. Cam assembly

gg. Rod-rake connector

hh. Ejector lever arm

ii. Shoulder screw

jj. Mold heater

kk. Ejector rod

ll. Finned duct

mm. Safety thermostat

9. a. 6

b. 5

c. 1

d. 3

e. 2

f. 4

10. Discussion should include:

a. Water enters ice tray

b. Water freezes in tray

c. Ice maker thermostat closes at 15°F

d. Thermostat moves a lever arm which actuates motor switch

e. Motor starts turning gear mechanism

f. Sensor arm moves down into cube storage bin

g. Cube tray begins to rotate

h. At approximately 180 degrees one corner of the tray contacts a stop

i. Shaft continues to turn twisting the tray

j. Tray stop is retracted

k. Tray is rapidly released from its twisted position shaking the cubes into the storage bin

l. Tray continues to turn until it has completed a 360 degree revolution

m. Water fill switch is energized

11. a. 4
b. 5
c. 1
d. 2
e. 6
f. 3

12. a. Saddle valve
b. Filter screen
c. Guide
d. Flow washer
e. Diaphragm
f. Spring
g. Armature
h. Solenoid coil
i. Fill valve

13. Performance skills evaluated to the satisfaction of the instructor

FUNDAMENTALS OF WINDOW AIR CONDITIONERS
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to match terms associated with window air conditioners to the correct definitions and discuss major components of window air conditioners. The student should also be able to match wire size to their current carrying capacities and identify window air conditioner parts. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with window air conditioners to the correct definitions.
2. List the five functions of a window air conditioner.
3. Identify window air conditioner cabinet parts.
4. Identify window air conditioner parts.
5. Match electrical receptacle design to the volt-amp requirements.
6. Match wire size to current carrying capacity.
7. Identify parts of the window.
8. List seventeen steps in the procedure for installing a window air conditioner.
9. Discuss major components of window air conditioners.
10. Demonstrate the ability to install a window air conditioner.

FUNDAMENTALS OF WINDOW AIR CONDITIONING
UNIT I

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate and discuss the procedures outlined in the job sheet.

   G. Obtain several different brands of window air conditioners for shop practice.

   H. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Complete job sheet.

   D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM 1--Window Air Conditioner Cabinet Parts

      2. TM 2--Window Air Conditioner Parts

      3. TM 3--Window Parts

      4. TM 4--Major Electrical Components

D. Job Sheet #1--Install a Window Air Conditioner

E. Test

F. Answers to test

II. References:

A. *Refrigeration, Part II.* Benton Harbor, Michigan: Whirlpool Corporation, 1974.

B. *Room Air Conditioner Installation, STM-65.* Dayton, Ohio: Air Temp Division/Chrysler Corporation.

FUNDAMENTALS OF WINDOW AIR CONDITIONERS
UNIT I

INFORMATION SHEET

I. Terms and definitions

   A. Window air conditioner--A refrigeration device which is placed in a window or through the wall to control temperature, humidity, cleanliness, and movement of air in a limited space

   B. Slinger ring--Metal ring on the outer edge of the condenser fan blades which picks up the condensate and sprays it across the condenser

   C. Escutcheon--The decorative cover panel on the control panel

   D. Condensation--Liquid which occurs when a gas or vapor is cooled below its dew point

   E. Sash--The portion of a double hung window which slides up and down

   F. Caulking compound--A heavy paste used for sealing a joint to make it air or watertight

   G. Air filter--Device for removing impurities from the air

II. Functions of a window air conditioner

   A. Removes sensible heat from the room air

   B. Lowers the humidity by removing moisture from the room air

   C. Ventilates by providing means to introduce outside air into the room

   D. Filters the room air as it passes through

   E. Circulates the air in the room

III. Window air conditioner cabinet parts (Transparency 1)

   (NOTE: There may be some slight variations to these parts by different manufacturers.)

   A. Cabinet

   B. Sash angle gasket

   C. Sash angle

   D. Window seal

INFORMATION SHEET

- E. Sash lock bracket
- F. Side channel window
- G. Side panel
- H. Seal bottom of side panel
- I. Side channel cabinet
- J. Cabinet seal
- K. Support bracket
- L. Sill channel
- M. Sill seal

IV. Window air conditioner parts (Transparency 2)

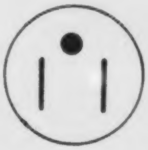
- A. Compressor
- B. Evaporator
- C. Condenser
- D. Blower motor
- E. Motor mount grommets
- F. Condenser fan
- G. Evaporator fan
- H. Filter
- I. Front grille
- J. Thermostat
- K. Control switch
- L. Dual capacitor
- M. Compressor mount
- N. Control panel
- O. Control panel escutcheon
- P. Power supply cord

7

INFORMATION SHEET

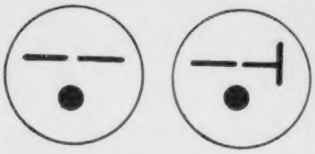
V. Receptacle design and volt-amp requirements

A.



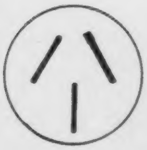
--115 volt; 15 amp

B.



--230 volt; 15 amp

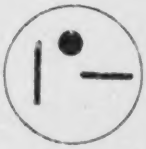
C.



--230/208 volt; 20 amp

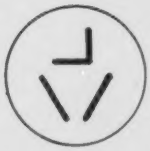
(NOTE: This receptacle is obsolete and is being replaced by the receptacle under "D".)

D.



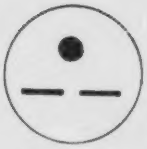
--230/208 volt; 20 amp

E.



--230/208 volt; 30 amp

F.



--230/208 volt; 30 amp

INFORMATION SHEET

VI. Wire sizes and current carrying capacities

(NOTE: An article of the National Electrical Code pertains to refrigeration equipment. Refer to this section when in doubt of code requirements.)

A. 12 gauge wire will carry 20 amps maximum

B. 10 gauge wire will carry 30 amps maximum

C. 8 gauge wire will carry 40 amps maximum

(NOTE: The above amperage ranges will cover most window air conditioner applications. Some window air conditioners may draw less than 20 amps of current but do not use any supply voltage wiring smaller than 12 gauge. If running more than 50 feet of conductor check for voltage drop.)

VII. Parts of a window (Transparency 3)

(NOTE: These parts are for the common double hung window.)

A. Casing

B. Frame

C. Sash

D. Sill

E. Apron

VIII. Procedure for installing a window air conditioner

A. Attach side channels to window casing

B. Attach side channels to cabinet

C. Attach sill channel and seal to window sill

D. Attach sash angle and gasket to cabinet

E. Center cabinet in window

F. Attach cabinet to sill channel

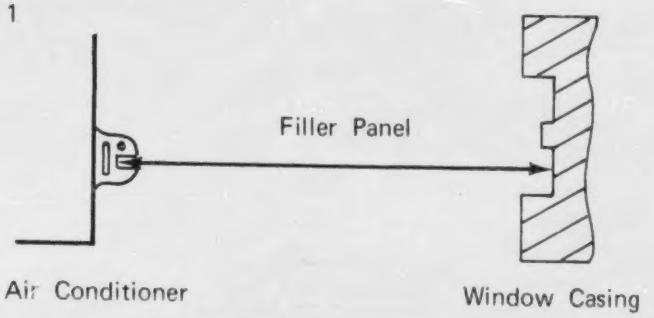
G. Attach support bracket to cabinet

INFORMATION SHEET

H. Cut filler panels 1/8 inch smaller than space (Figure 1)

(NOTE: Undercutting the panels enables them to slide in easier.)

FIGURE 1


Filler Panel
Air Conditioner
Window Casing

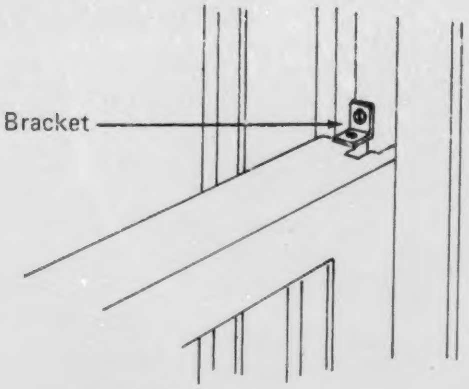
I. Slide side panel into channels

(NOTE: Before the side panels reach the window sill place the bottom seal on them.)

J. Lower sash

K. Install sash lock brackets (Figure 2)

FIGURE 2



L. Fasten cabinet sash angle to sash

M. Place window seal in place

N. Install cabinet seal

INFORMATION SHEET

O. Check to see that the back of the cabinet tilts slightly downward

(NOTE: Never have the back of the air conditioner higher than the front because this would allow the condensate to run into the house.)

P. Caulk around outside of window

Q. Install front grille

IX. Major components of window air conditioners (Transparency 4)

A. Compressor

1. PSC (Permanent split capacitor)
2. No relay and start capacitor

B. Hard start kit

(NOTE: The addition of a starting relay and capacitor to a P.S.C. compressor is referred to as a hard start kit.)

1. Potential relay
2. Start capacitor

C. Fan motor condenser and evaporator

1. Double shaft
2. Two or three speed

D. Dual run capacitor

1. Compressor
2. Fan

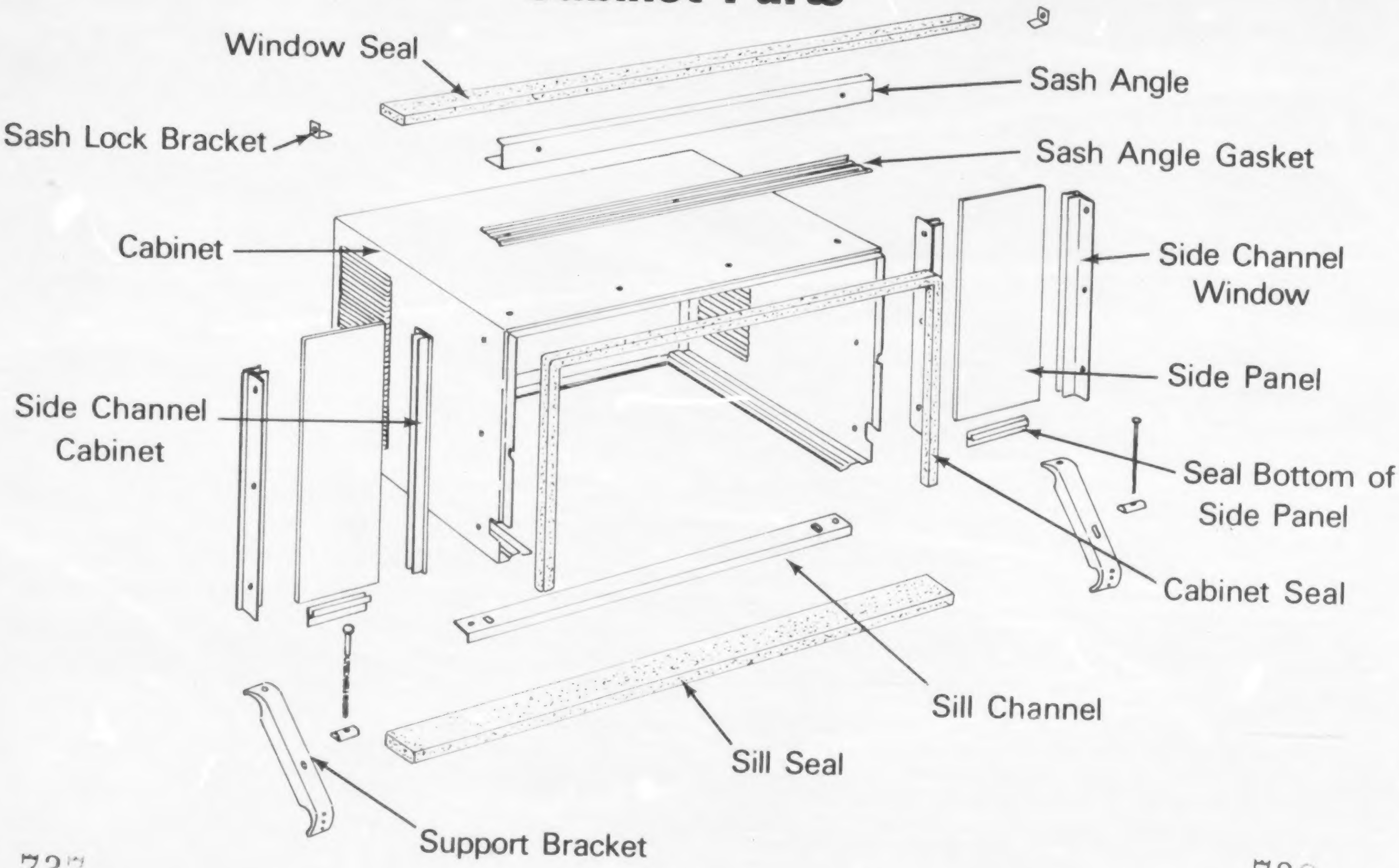
E. Thermostat

1. Line voltage
2. Cycle compressor only

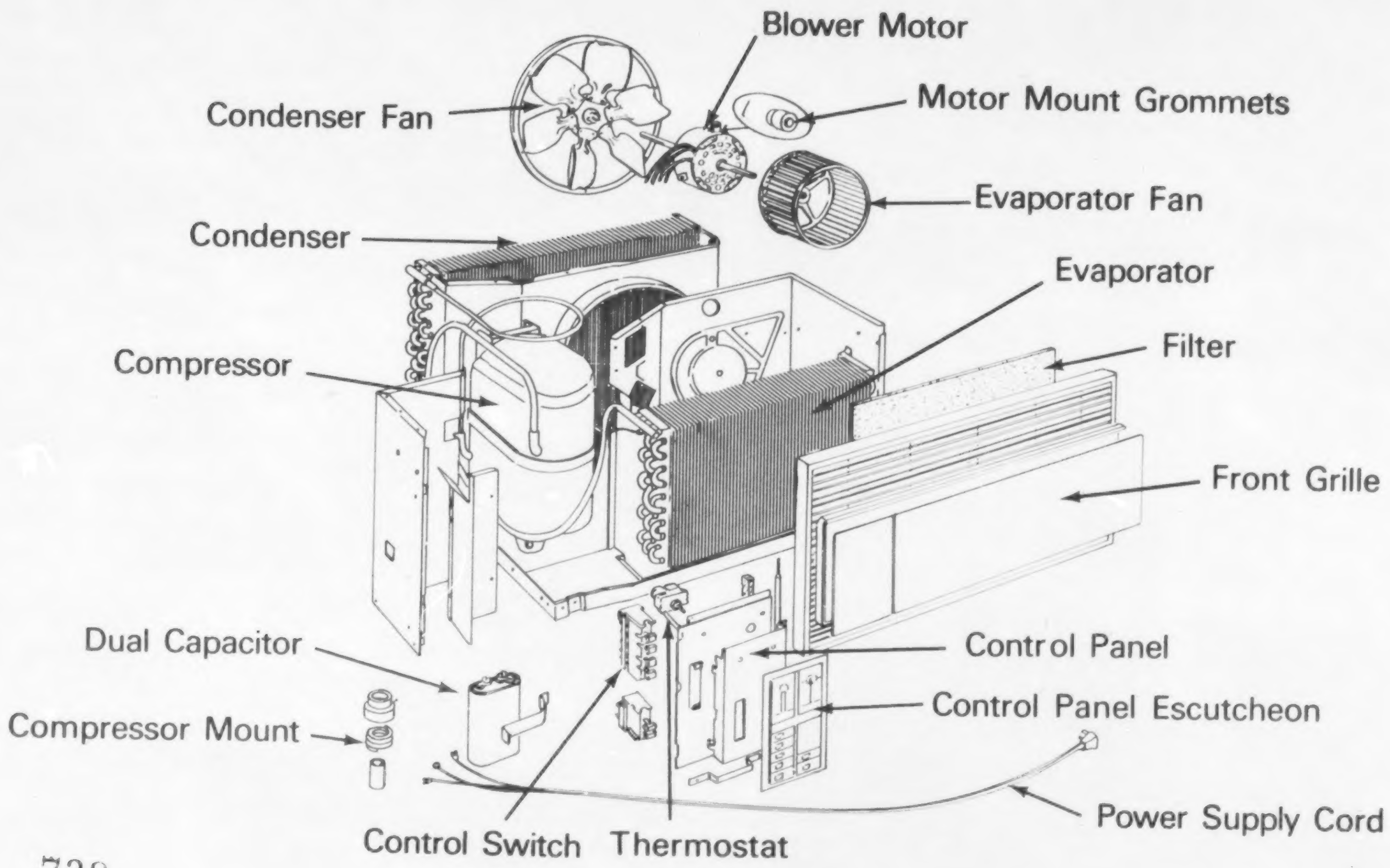
F. Control switch

1. On/off switch for entire system
2. Fan speed selection switch

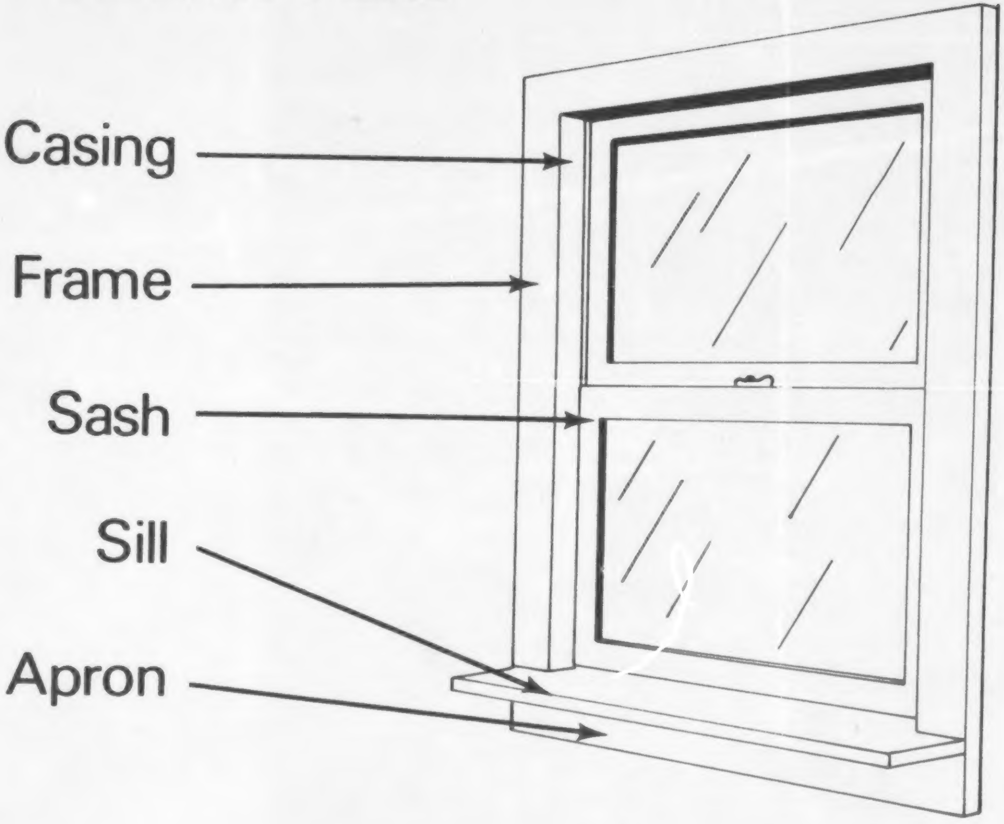
Window Air Conditioner
Cabinet Parts


Window Seal
Sash Angle
Sash Lock Bracket
Sash Angle Gasket
Cabinet
Side Channel Window
Side Panel
Side Channel Cabinet
Seal Bottom of Side Panel
Cabinet Seal
Sill Channel
Sill Seal
Support Bracket

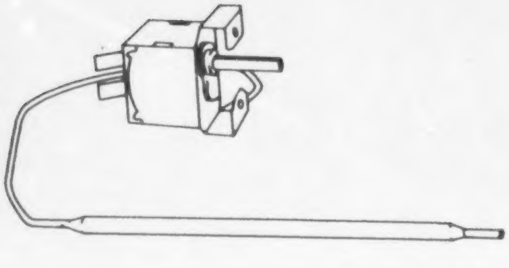
Window Air Conditioner Parts


Blower Motor
Condenser Fan
Motor Mount Grommets
Evaporator Fan
Condenser
Evaporator
Compressor
Filter
Front Grille
Dual Capacitor
Control Panel
Control Panel Escutcheon
Compressor Mount
Power Supply Cord
Control Switch
Thermostat

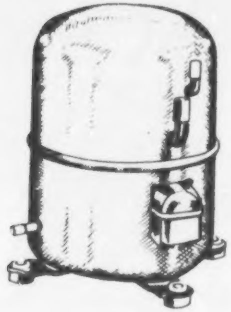
Window Parts


Casing
Frame
Sash
Sill
Apron

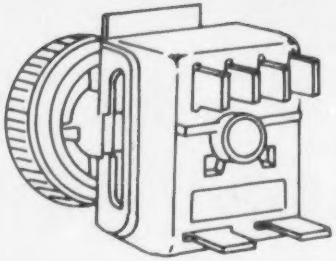
Major Electrical Components



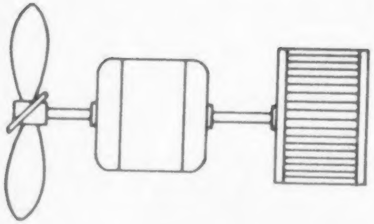
Thermostat



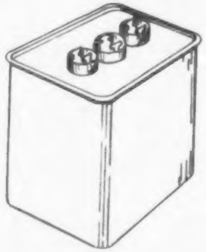
PSC Compressor



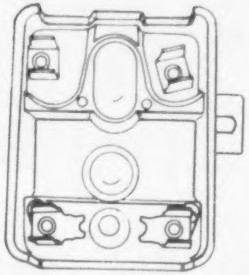
Control Switch



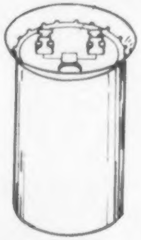
Fan Motor



Dual Run Capacitor



Relay



Capacitor

Hard Start Kit

FUNDAMENTALS OF WINDOW AIR CONDITIONERS
UNIT I

JOB SHEET #1--INSTALL A WINDOW AIR CONDITIONER

I. Tools and materials

   A. Standard slot type screwdriver

   B. Scatch awl

   C. Caulking gun

   D. Caulking compound

   E. Flexible tape measure

   F. Hand saw

II. Procedure

   A. Carefully uncrate air conditioner

   B. Remove shipping bolts and brackets

   C. Slide air conditioner out of cabinet

   D. Locate window in which air conditioner is to be installed

   E. Attach side channels to window casing

   F. Attach side channels to cabinet

   G. Attach sill channel and seal to window sill

   H. Attach sash angle and gasket to cabinet

   I. Center cabinet in window

   J. Attach cabinet to sill channel

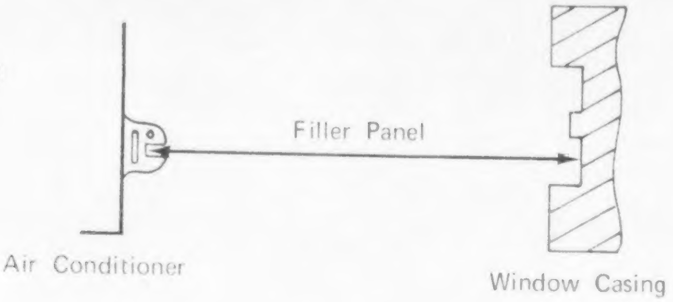
   K. Attach support bracket to cabinet

JOB SHEET #1

L. Cut filler panels 1/8 inch smaller than space (Figure 1)

(NOTE: Undercutting the panels enables them to slide in easier.)

FIGURE 1


Filler Panel
Air Conditioner
Window Casing

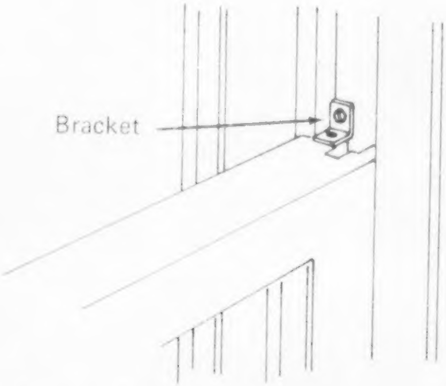
M. Slide side panel into channels

(NOTE: Before the side panels reach the window sill place the bottom seal on them.)

N. Lower sash

O. Install sash lock brackets (Figure 2)

FIGURE 2



P. Fasten cabinet sash angle to sash

Q. Place window seal in place

R. Slide air conditioner into cabinet

S. Install cabinet seal

JOB SHEET #1

T. Check to see that the back of the cabinet tilts slightly downward

(NOTE: Never have the back of the air conditioner higher than the front because this would allow the condensate to run into the house.)

U. Caulk around outside of window

V. Install front grille

W. Plug in air conditioner

X. Turn on air conditioner

Y. Check operation

Z. Have instructor check

AA. Clean up and put away tools and materials

FUNDAMENTALS OF WINDOW AIR CONDITIONERS
UNIT I

NAME ____________________

TEST

1. Match the terms on the right to their correct definitions.

_____a. Liquid which occurs when a gas or vapor is cooled below its dew point

_____b. Metal ring on the outer edge of the condenser fan blades which picks up the condensate and sprays it across the condenser

_____c. The decorative cover panel on the control panel

_____d. A refrigeration device which is placed in a window or through the wall to control temperature, humidity, cleanliness, and movement of air in a limited space

_____e. Device for removing impurities from the air

_____f. The portion of a double hung window which slides up and down

_____g. A heavy paste used for sealing a joint to make it air or watertight

1. Slinger ring
2. Window air conditioner
3. Caulking Compound
4. Escutcheon
5. Condensation
6. Air filter
7. Sash

2. List the five functions of a window air conditioner.

a.

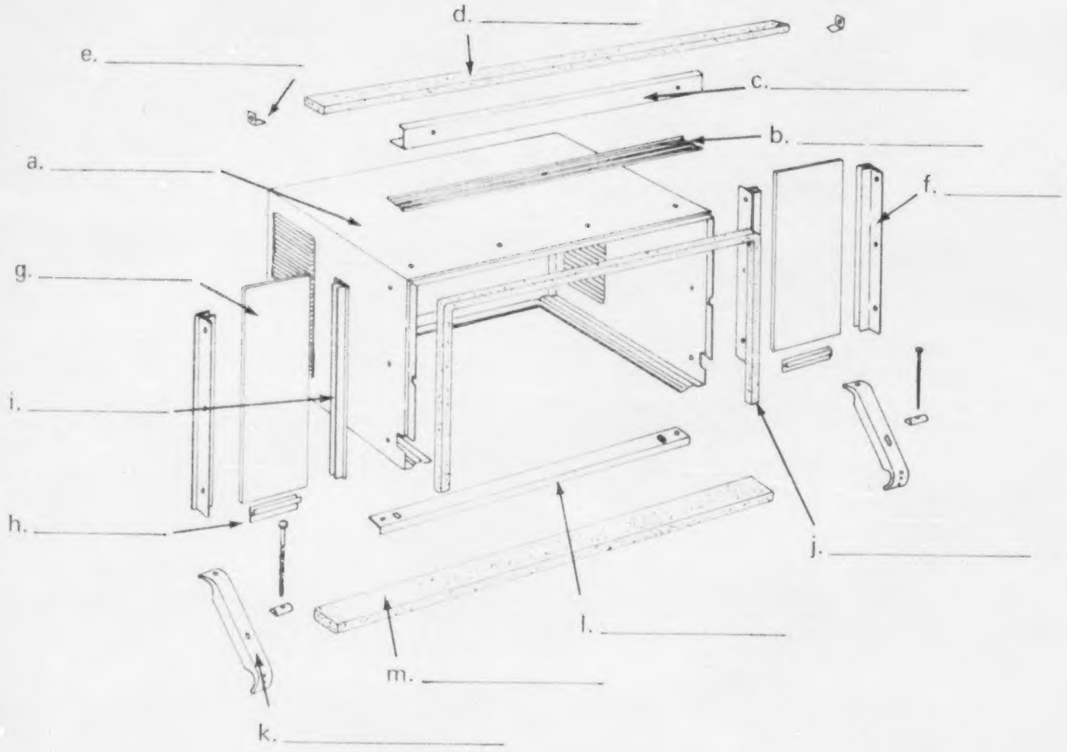
b.

c.

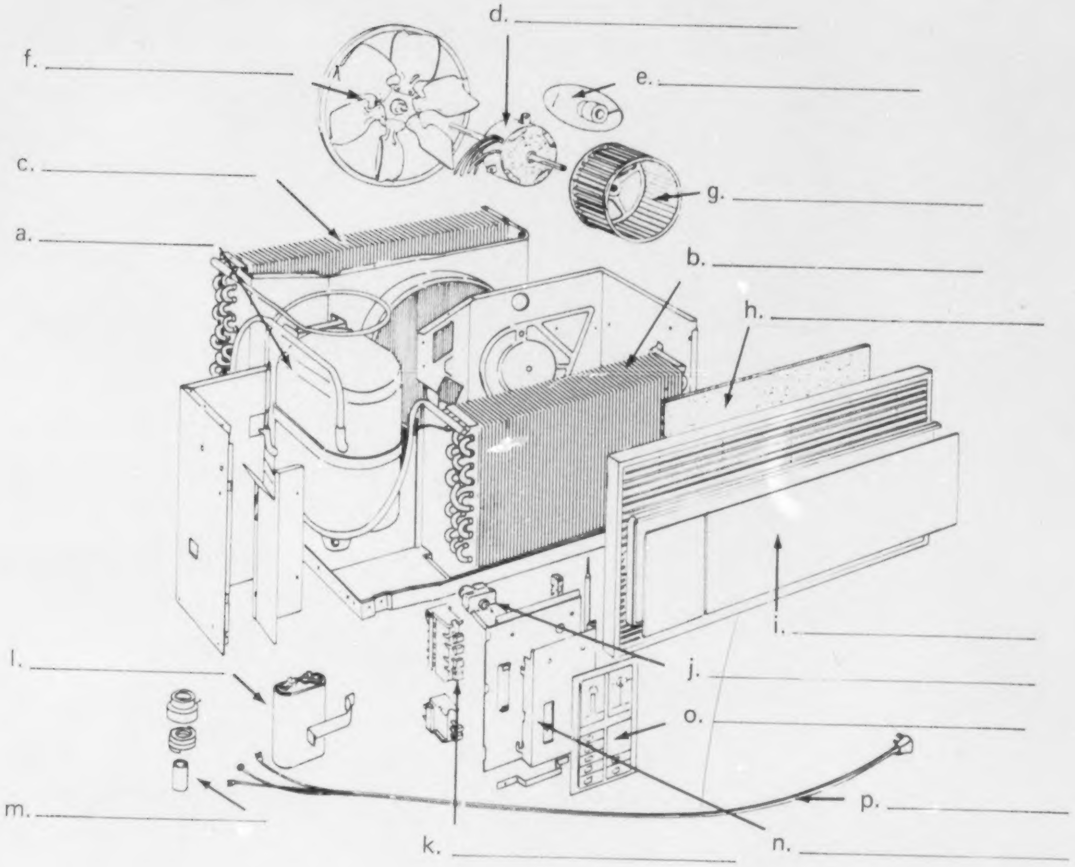
d.

e.

3. Identify window air conditioner cabinet parts.

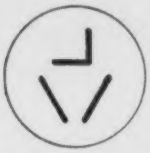

d. ____________
e. ____________
c. ____________
b. ____________
a. ____________
f. ____________
g. ____________
i. ____________
h. ____________
j. ____________
l. ____________
m. ____________
k. ____________

4. Identify window air conditioner parts.

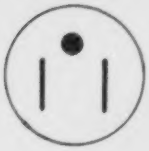

d. ______________________
f. ______________________
e. ______________________
c. ______________________
g. ______________________
a. ______________________
b. ______________________
h. ______________________
i. ______________________
j. ______________________
l. ______________________
o. ______________________
m. ______________________
p. ______________________
k. ______________________
n. ______________________

5. Match the volt-amp requirements on the right to the correct receptacles.

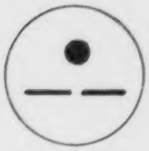
_____ a.



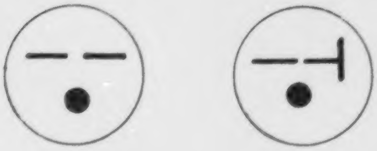
_____ b.



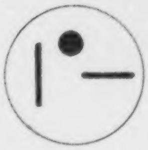
_____ c.



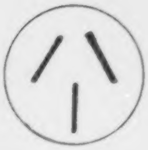
_____ d.



_____ e.



_____ f.

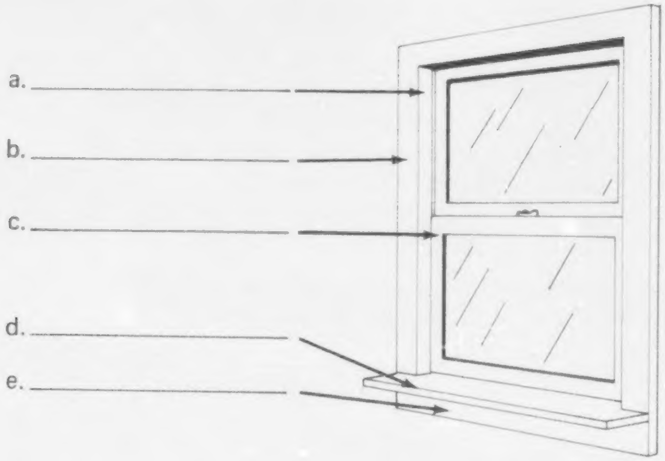


1. 230/208 volt; 30 amp
2. 115 volt; 15 amp
3. 230/208 volt; 20 amp
4. 230 volt; 15 amp

6. Match the wire size on the right to the correct current carrying capacity.

_____a. 40 amps	1.	10 gauge
_____b. 20 amps	2.	12 gauge
_____c. 30 amps	3.	8 gauge

7. Identify parts of the window.



8. List seventeen steps in the procedure of installing a window air conditioner.

a.

b.

c.

d.

e.

f.

g.

h.

i.

j.

k.

l.

m.

n.

o.

p.

q.

9. Discuss major components of window air conditioners.

   a. Compressor

      1)

      2)

   b. Hard start kit

      1)

      2)

   c. Fan motor

      1)

      2)

   d. Dual run capacitor

      1)

      2)

   e. Thermostat

      1)

      2)

   f. Control switch

      1)

      2)

10. Demonstrate the ability to install a window air conditioner.

(NOTE: If this activity has not been accomplished prior to the test, ask your instructor when it should be completed.)

FUNDAMENTALS OF WINDOW AIR CONDITIONERS
UNIT I

ANSWERS TO TEST

1. a. 5　e. 6

   b. 1　f. 7

   c. 4　g. 3

   d. 2

2. a. Removes sensible heat from the room air

   b. Lowers the humidity by removing moisture from the room air

   c. Ventilates by providing means to introduce outside air into the room

   d. Filters the room air as it passes through

   e. Circulates the air in the room

3. a. Cabinet

   b. Sash angle gasket

   c. Sash angle

   d. Window seal

   e. Sash lock bracket

   f. Side channel window

   g. Side panel

   h. Seal bottom of side panel

   i. Side channel cabinet

   j. Cabinet seal

   k. Support bracket

   l. Sill channel

   m. Sill seal

4. a. Compressor
   b. Evaporator
   c. Condenser
   d. Blower motor
   e. Motor mount grommets
   f. Condenser fan
   g. Evaporator fan
   h. Filter
   i. Front grille
   j. Thermostat
   k. Control switch
   l. Dual capacitor
   m. Compressor mount
   n. Control panel
   o. Control panel escutcheon
   p. Power supply cord

5. a. 1
   b. 2
   c. 1
   d. 4
   e. 3
   f. 3

6. a. 3
   b. 2
   c. 1

7. a. Casing
   b. Frame
   c. Sash
   d. Sill
   e. Apron

8. a. Attach side channels to window casing
   b. Attach side channels to cabinet
   c. Attach sill channel and seal to window sill
   d. Attach sash angle and gasket to cabinet
   e. Center cabinet in window
   f. Attach cabinet to sill channel
   g. Attach support bracket to cabinet
   h. Cut filler panels 1/8 inch smaller than space
   i. Slide side panel into channels
   j. Lower sash
   k. Install sash lock brackets
   l. Fasten cabinet sash angle to sash
   m. Place window seal in place
   n. Install cabinet seal
   o. Check to see that the back of the cabinet tilts slightly downward
   p. Caulk around outside of window
   q. Install front grille

9. Discussion should include:
   a. Compressor
      1) PSC (Permanent Split Capacitor)
      2) No relay and start capacitor
   b. Hard start kit
      1) Potential relay
      2) Start capacitor
   c. Fan motor condenser and evaporator
      1) Double shaft
      2) Two or three speed

- d. Dual run capacitor
  - 1) Compressor
  - 2) Fan
- e. Thermostat
  - 1) Line voltage
  - 2) Cycle compressor only
- f. Control switch
  - 1) On/off switch for entire system
  - 2) Fan speed selection switch

10. Performance skill evaluated to the satisfaction of the instructor

WINDOW AIR CONDITIONER REPAIR
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to match terms to the correct definitions, discuss data plates, identify schematic components, and match window air conditioner problems to remedies and checks. The student should also be able to check components, clean a condenser, replace a fan motor and install a hard start kit. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with window air conditioning to the correct definitions.
2. List the nine items of information given on a window air conditioner data plate.
3. Discuss compressor motor data plates.
4. Identify schematic components.
5. Match window air conditioner problems to remedies and checks.
6. Demonstrate the ability to:
    a. Check control switch with an ohmmeter.
    b. Clean a condenser.
    c. Replace a fan motor.
    d. Install a hard start kit.

WINDOW AIR CONDITIONER REPAIR
UNIT II

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparency.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate and discuss the procedures outlined in the job sheets.

   G. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Complete job sheets.

   D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency master: TM 1--Window Air Conditioner Schematic

   D. Job sheets

      1. Job Sheet #1--Check Control Switch with an Ohmmeter

      2. Job Sheet #2--Clean a Condenser

3. Job Sheet #3--Replace a Fan Motor
4. Job Sheet #4--Install a Hard Start Kit

E. Test

F. Answers to test

II. References:

A. *Room Air Conditioner In-Shop Service. STM74.* Dayton, Ohio: Air Temp Division/Chrysler Corp.

B. *Refrigeration, Part II.* Benton Harbor, Michigan: Whirlpool Corp., 1974.

WINDOW AIR CONDITIONER REPAIR
UNIT II

INFORMATION SHEET

I. Terms and definitions

   A. E.E.R. (Energy Efficiency Ratio)--Ratio calculated by dividing the cooling capacity in Btu/h by the power input in watts at any given set of rating conditions, expressed in Btu/h per watt

   B. N.E.M.A. (National Electrical Manufacturer's Association)--Sets voluntary standards for motors and appliances

   C. U.L. (Underwriter's Laboratories)--Tests air conditioners to see that they meet the electrical safety requirements of the American National Standard for air conditioners

   D. A.H.A.M. (Association of Home Appliance Manufacturers)--Certifies the heating and cooling capacity ratings and electrical inputs of all air conditioners bearing their seal

II. Window air conditioner data plate

   A. Model number

   B. Serial number

   C. Refrigerant type and amount

   D. F.L.A. (full load amperage)

   E. L.R.A. (locked rotor amperage)

   F. Wattage

   G. E.E.R.

   H. N.E.M.A. and/or U.L. approval

   I. Btu/h capacity

III. Compressor motor data plates

   (NOTE: The information provided on a compressor motor data plate will be needed in ordering a replacement compressor motor.)

   A. Location of data plate

      1. Top of compressor motor

      2. Side of compressor motor

INFORMATION SHEET

B. Information on data plate

1. Compressor motor model number
2. Compressor motor serial number
3. L.R.A. (locked rotor amperage)
4. F.L.A. (full load amperage)

   (NOTE: Not all manufacturers include this information on their data plates.)

5. Voltage
6. Phase
7. Cycle (hertz)
8. Horsepower
9. Letter codes
   a. Motor manufacturer
   b. Month and year of manufacture
   c. Shift
   d. Plant

(NOTE: The information pertains only to the compressor motor and the compressor motor manufacturer which is generally different than the equipment manufacturer.)

IV. Schematic components (Transparency 1)

A. Control switch

B. Fan motor

C. Fan motor run capacitor

D. Compressor motor run capacitor

(NOTE: These two capacitors are often encased in one container and are referred to as a dual capacitor.)

E. Thermostat

F. Bimetal overload

G. Compressor motor - P.S.C.

INFORMATION SHEET

V. Window air conditioner problems, remedies, and checks

   A. Air conditioner will not run

      1. Check voltage at receptacle

      2. Replace fuse or reset circuit breaker

      3. Check voltage at control switch

   B. Fan motor runs, but compressor motor won't

      1. Check thermostat

      2. Check compressor motor wiring

      3. Check run capacitor

      4. Check overload

      5. Check for low voltage at compressor motor terminals

      6. Check start capacitor

      7. Check potential relay

   (NOTE: The start capacitor and potential relay will only exist if they have been added for hard starting problems.)

   C. Air conditioner circuit protection device opens

      1. Check wiring

      2. Check for shorted capacitors

      3. Check for stuck or grounded compressor

      4. Check thermostat for short cycling

      5. Check compressor motor starting ability

         (NOTE: If the compressor motor appears hard to start a hard start kit may need to be added to the system.)

      6. Check starting and running amperage

      7. Check size of circuit protection device

INFORMATION SHEET

D. Compressor motor short cycles
   1. Check for low voltage
   2. Check for sufficient air flow across condenser
   3. Clean condenser
   4. Check location of thermostat sensing element
   5. Check amperage draw and overload

E. Air conditioner vibrates or rattles
   1. Check for shipping bolts and blocks
   2. Check for refrigerant lines against the cabinet
   3. Check for loose panels or components
   4. Check fan motor alignment
   5. Check for loose fan blades or hubs

F. Water leaks from air conditioner
   1. Tilt back of cabinet downward
   2. Clean condensate drain
   3. Check for leaking in evaporator drip pan
   4. Check for ice on evaporator

G. Noisy fan
   1. Check for fan hitting shroud
   2. Tighten fan hub on shaft
   3. Check fan blades
   4. Check fan mounting

H. Air conditioner is not cooling properly
   1. Clean air filter
   2. Close outside air intake
   3. Check for blocked condenser
   4. Clean condenser

INFORMATION SHEET

   5. Check to see that the compressor motor is running
   6. Check refrigerant charge and pressures

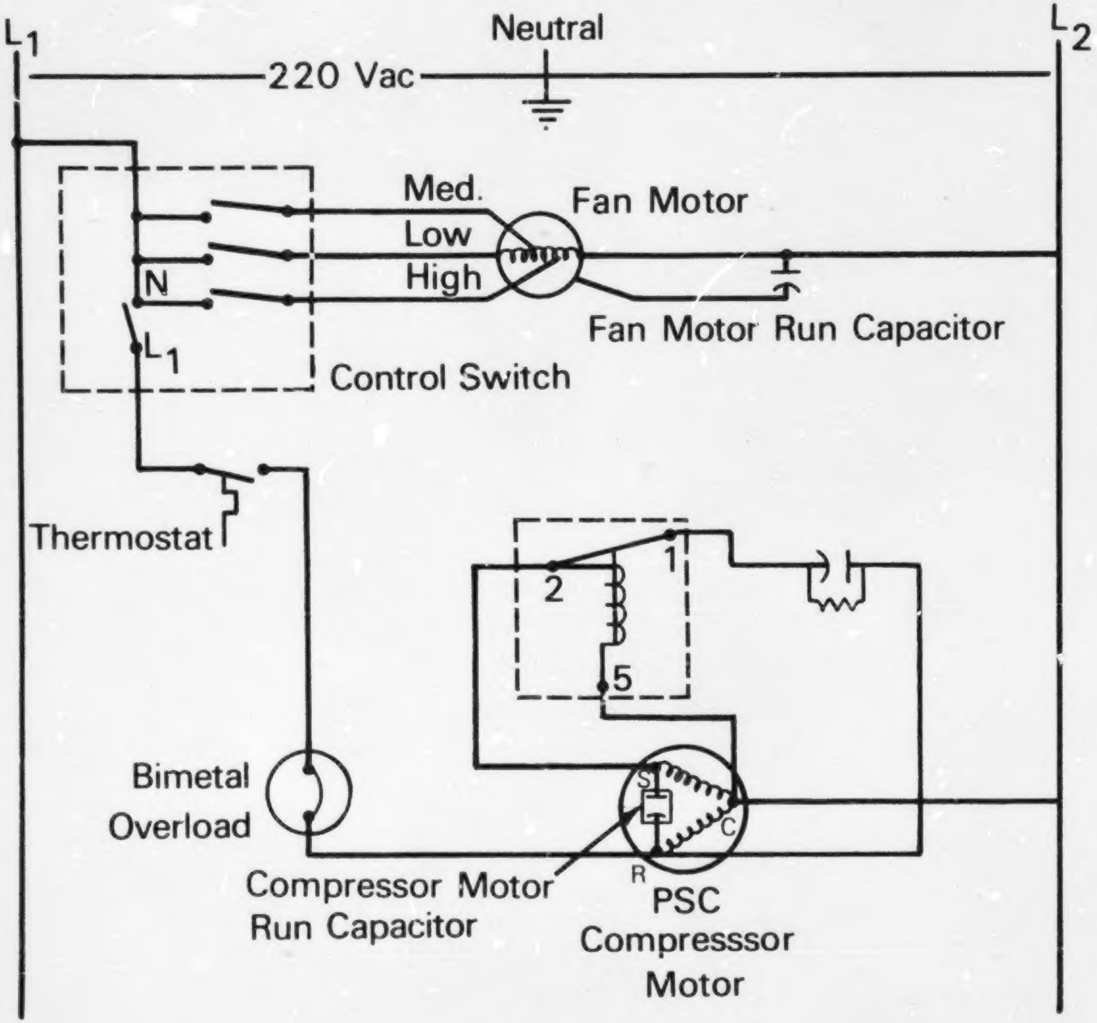
I. Ice on evaporator

   1. Clean air filter
   2. Check fan motor operation
   3. Check refrigerant pressures
   4. Clean evaporator
   5. Check thermostat setting

J. Compressor motor runs but fan won't

   1. Check fan blade for binding
   2. Check wiring
   3. Check selector switch
   4. Check run capacitor
   5. Check fan motor

Window Air Conditioner Schematic


L1
Neutral
L2
220 Vac
Med.
Low
High
N
L1
Fan Motor
Fan Motor Run Capacitor
Control Switch
Thermostat
2
1
5
Bimetal Overload
S
C
R
Compressor Motor Run Capacitor
PSC Compresssor Motor

WINDOW AIR CONDITIONER REPAIR
UNIT II

JOB SHEET #1--CHECK CONTROL SWITCH WITH AN OHMMETER

I. Tools and materials

  A. Control switch

  B. Ohmmeter

  C. Window air conditioner

  D. Screwdriver

  E. Long nose pliers

  F. Masking tape

II. Procedure

(CAUTION: Never check a component with an ohmmeter when power is applied.)

  A. Mark control switch wires with masking tape

  (NOTE: It is not recommended to use duct tape for this purpose as pencil or pen markings will easily rub off of duct tape.)

  B. Remove wires from switch

  C. Remove switch from air conditioner

  D. Place ohmmeter in the R x 1 position

  E. Zero ohmmeter

  F. Attach one ohmmeter lead to L_1

  G. Place switch in the "off" position

  H. Touch the other ohmmeter lead to terminals (1, 2, 3, and 4) one at a time

  I. Watch meter when touching each terminal

  (NOTE: If the needle moves when touching any of the terminals the contacts are shorted and the switch must be discarded.)

  J. Select the high fan position on the control switch

JOB SHEET #1

K. Touch unattached lead to terminals 1, 2, 3, and 4

(NOTE: Continuity must only be indicated between L_1 and #4.)

L. Select the low fan position on the control switch

M. Touch unattached lead to terminals 1, 2, 3, and 4

(NOTE; Continuity must only be indicated between L_1 and #3.)

N. Select the high cool position on the control switch

O. Touch the unattached lead to terminals 1, 2, 3, and 4

(NOTE: Continuity must only be indicated between L_1 and #2 and L_1 and #1.)

P. Select the normal cool position on the control switch

Q. Touch the unattached lead to terminals 1, 2, 3, and 4

(NOTE: Continuity must only be indicated between L_1 and #4 and L_1 and #1.)

R. Select the low cool position on the control switch

S. Touch the unattached lead to terminals 1, 2, 3, and 4

(NOTE: Continuity must only be indicated between L_1 and #3 and L_1 and #1.)

T. Reinstall control switch in air conditioner

(NOTE: If the switch was found to be defective in any of the checks above it should be replaced.)

U. Connect wires to switch

V. Have instructor check

W. Connect air conditioner to electrical power

X. Start air conditioner and check various switch positions

Y. Stop air conditioner

Z. Disconnect air conditioner from electrical power

AA. Clean up and put away tools and materials

WINDOW AIR CONDITIONER REPAIR
UNIT II

JOB SHEET #2--CLEAN A CONDENSER

I. Tools and materials

   A. Window air conditioner

   B. Plastic bag

   C. Degreasing solvent

   D. Water hose

   E. Spray nozzle

II. Procedure

   A. Remove air conditioner from cabinet

   (CAUTION: Always have help when lifting heavy awkward objects.)

   B. Set air conditioner close to a floor drain or outside

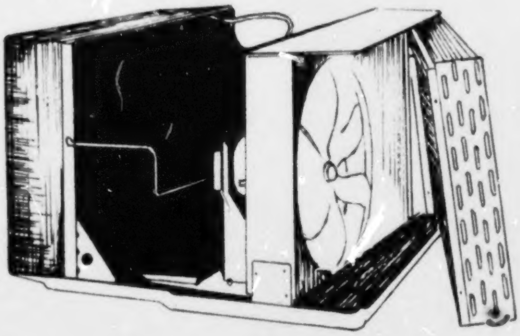
   C. Wrap fan motor with a plastic bag

   (NOTE: If water enters the fan motor it will be ruined.)

   D. Remove screws which hold condenser to fan shroud

   E. Carefully swing condenser out (Figure 1)

FIGURE 1



(CAUTION: Do not swing the condenser out far enough to kink or break refrigerant lines.)

   F. Spray degreasing solvent on condenser

   G. Allow solvent time to work

JOB SHEET #2

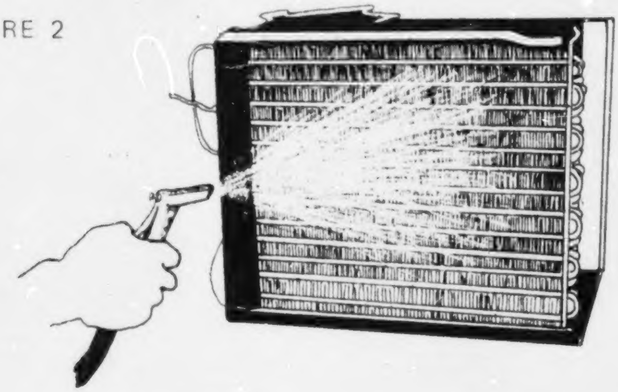
H. Attach water hose to hydrant

(NOTE: If using hot water be sure the hose is designed for use with hot water.)

I. Attach spray nozzle to water hose

J. Spray condenser with water (Figure 2)

FIGURE 2



K. Tilt air conditioner sideways so water will run out

L. Remove plastic bag from fan motor

M. Dry all electrical components with a shop towel

N. Carefully move condenser back into proper position

O. Replace screws which hold the condenser to the shroud

P. Have instructor check

Q. Replace air conditioner in cabinet

R. Clean up and put away tools and materials

WINDOW AIR CONDITIONER REPAIR
UNIT II

JOB SHEET #3--REPLACE A FAN MOTOR

I. Tools and materials

   A. Standard slot type screwdriver

   B. Phillips screwdriver

   C. Nutdriver 1/4"

   D. Open end wrenches

   E. Long nose pliers

   F. Hex key wrenches

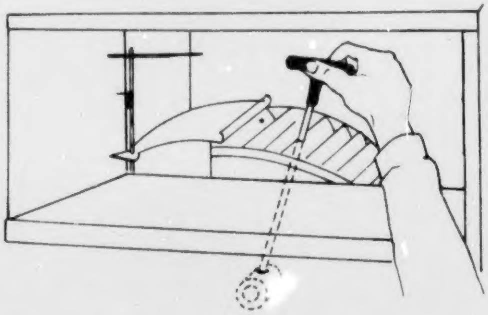
   G. Ammeter

II. Procedure

   A. Remove air conditioner from cabinet

   B. Loosen set screw in evaporator fan hub (Figure 1)

FIGURE 1



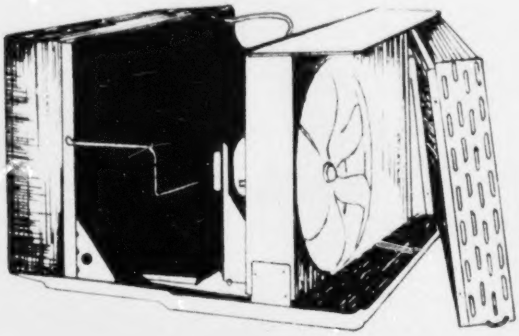
   C. Remove motor wires from control switch

   D. Remove screws which hold condenser to fan shroud

JOB SHEET #3

E. Carefully swing condenser out a slight amount (Figure 2)

FIGURE 2



F. Remove set screw from condenser fan hub

G. Slide condenser fan off of motor shaft

H. Remove bolts that hold the fan motor cradle to the air conditioner

I. Remove motor and cradle

J. Check direction of rotation

K. Check for proper shaft length

(NOTE: A shaft which is too long may be cut off with a hacksaw but be sure the direction of rotation is correct before cutting off the shaft.)

L. Remove motor from cradle

M. Place new motor in cradle

N. Align motor shaft with evaporator blower hub

O. Replace fan motor cradle bolts

P. Lubricate motor shaft

Q. Slide condenser fan on shaft

R. Check to be sure that fans do not hit the shrouds

S. Tighten fan set screws

(NOTE: Care should be taken to be sure that the set screw is against the flat part of the shaft.)

T. Reinstall condenser into position

JOB SHEET #3

U. Replace screws which hold the condenser to the shroud

V. Place wires on control switch

W. Turn fan by hand to be sure the condenser fan is not hitting

X. Have instructor check

Y. Replace air conditioner in cabinet

Z. Check fan motor operation and amperage

WINDOW AIR CONDITIONER REPAIR
UNIT II

JOB SHEET #4--INSTALL A HARD START KIT

I. Tools and materials

   A. Window air conditioner

   B. Start capacitor with bleed resistor

   C. Potential relay

   D. Standard slot type screwdriver

   E. Phillips screwdriver

   F. 14 gauge stranded wire

   G. Wire connectors

   H. Side cutters

   I. Crimping tool

   J. Ammeter

   K. Ohmmeter

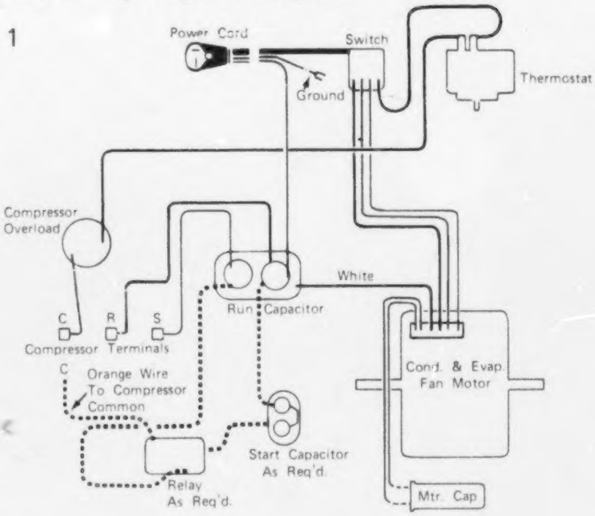
II. Procedure

   A. Remove air conditioner from cabinet

   B. Install relay and start capacitor in control compartment

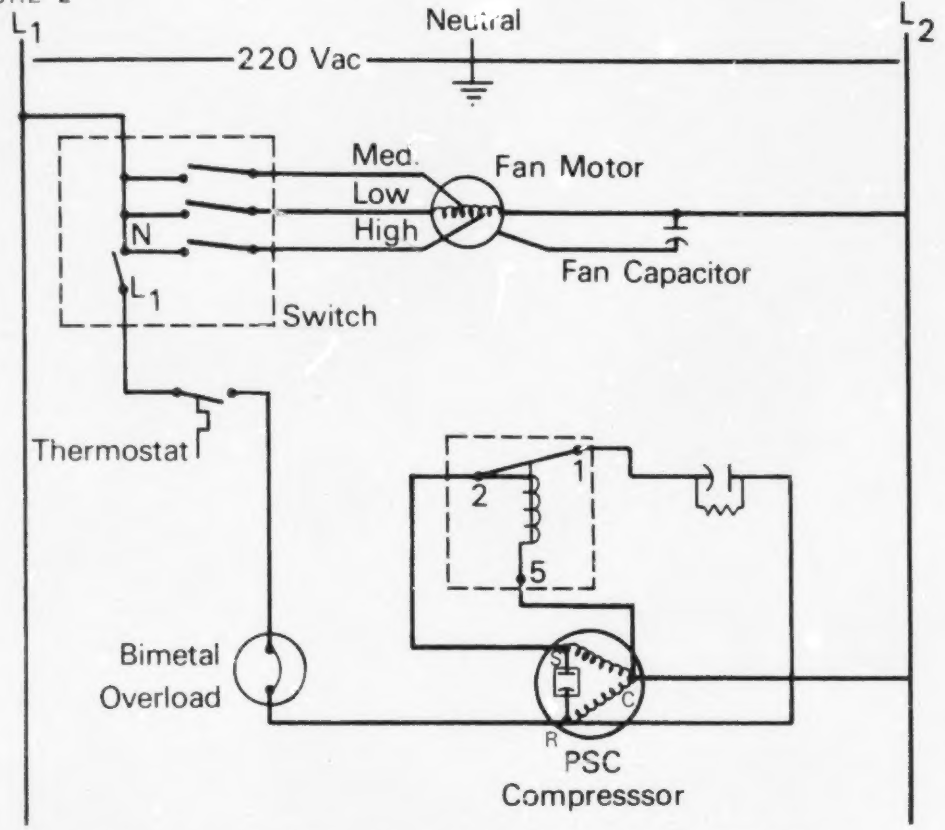
   C. Study wiring diagrams (Figures 1 and 2)

FIGURE 1


Power Cord
Switch
Ground
Thermostat
Compressor Overload
White
Run Capacitor
C
R
S
Compressor Terminals
C
Orange Wire To Compressor Common
Cond. & Evap. Fan Motor
Start Capacitor As Req'd.
Relay As Req'd.
Mtr. Cap

JOB SHEET #4

FIGURE 2


L_1
Neutral
L_2
220 Vac
Med.
Low
High
Fan Motor
N
L_1
Switch
Fan Capacitor
Thermostat
2
1
5
Bimetal
Overload
S
C
R
PSC
Compresssor

D. Connect a wire from #1 on relay to one side of start capacitor

E. Connect other side of start capacitor to line voltage terminal of run capacitor or run terminal

F. Connect a wire from #2 on relay to start on compressor motor

G. Connect a wire from #5 on relay to common on compressor motor

H. Have instructor check

I. Connect air conditioner to electrical power

J. Place ammeter in highest scale

K. Connect ammeter around the start wire

L. Turn on air conditioner

(NOTE: Starting amperage should only last a few seconds.)

JOB SHEET #4

M. Check running amperage

N. Have instructor check

O. Stop air conditioner

P. Disconnect air conditioner from electrical power

Q. Install air conditioner in cabinet

R. Clean up and put away tools and materials

WINDOW AIR CONDITIONER REPAIR
UNIT II

NAME ____________________

TEST

1. Match the terms on the right to the correct definitions.

_____a. Tests air conditioners to see that they meet the electrical safety requirements of the American National Standard for air conditioners

_____b. Ratio calculated by dividing the cooling capacity in Btu/h by the power input in watts at any given set of rating conditions, expressed in Btu/h per watt

_____c. Certifies the heating and cooling capacity ratings and electrical inputs of all air conditioners bearing their seal

_____d. Sets voluntary standards for motors and appliances

1. N.E.M.A. (National Electrical Manufacturer's Association)
2. U.L. (Underwriter's Laboratories)
3. A.H.A.M. (Association of Home Appliance Manufacturers)
4. E.E.R. (Energy Efficiency Ratio)

2. List the nine items of information given on a window air conditioner data plate.

a.

b.

c.

d.

e.

f.

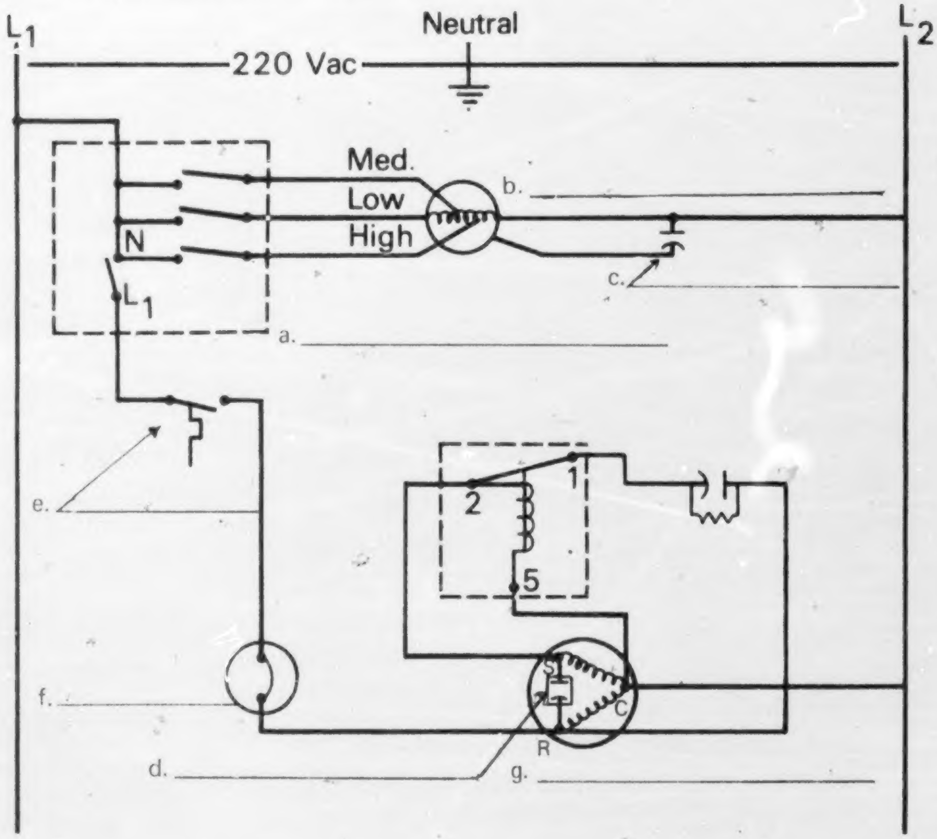
g.

h.

i.

3. Discuss compressor motor data plates.

4. Identify schematic components.


L1
Neutral
L2
220 Vac
Med.
Low
High
N
L1
b.
c.
a.
e.
2
1
5
S
C
R
f.
d.
g.

5. Match the window air conditioner problem on the left to the remedies and checks on the right.

______a.
1) Check wiring
2) Check for shorted capacitors
3) Check for stuck or grounded compressor
4) Check thermostat for short cycling
5) Check compressor motor starting ability
6) Check starting and running amperage
7) Check size of circuit protection device

______b.
1) Clean air filter
2) Close outside air intake
3) Check for blocked condenser
4) Clean condenser
5) Check to see that the compressor motor is running
6) Check refrigerant charge and pressures

______c.
1) Clean air filter
2) Check fan motor operation
3) Check refrigerant pressures
4) Clean evaporator
5) Check thermostat setting

______d.
1) Check thermostat
2) Check compressor motor wiring
3) Check run capacitor
4) Check overload
5) Check for low voltage at compressor motor terminals
6) Check start capacitor
7) Check potential relay

______e.
1) Tilt back of cabinet downward
2) Clean condensate drain
3) Check for leaking in evaporator drip pan
4) Check for ice on evaporator

______f.
1) Check voltage at receptacle
2) Replace fuse or reset circuit breaker
3) Check voltage at control switch

______g.
1) Check fan blade for binding
2) Check wiring
3) Check selector switch
4) Check run capacitor
5) Check fan motor

1. Compressor motor short cycles
2. Water leaks from air conditioner
3. Air conditioner will not run
4. Air conditioner circuit protection device opens
5. Air conditioner is not cooling properly
6. Air conditioner vibrates or rattles
7. Ice on evaporator
8. Fan motor runs, but compressor motor won't
9. Noisy fan
10. Compressor motor runs but fan won't

_____h.
1) Check for low voltage
2) Check for sufficient air flow across condenser
3) Clean condenser
4) Check location of thermostat sensing element
5) Check amperage draw and overload

_____i.
1) Check for shipping bolts and blocks
2) Check for refrigerant lines against the cabinet
3) Check for loose panels or components
4) Check fan motor alignment
5) Check for loose fan blades or hubs

_____j.
1) Check for fan hitting shroud
2) Tighten fan hub on shaft
3) Check fan blades
4) Check fan mounting

6. Demonstrate the ability to:

a. Check control switch with an ohmmeter.

b. Clean a condenser.

c. Replace a fan motor.

d. Install a hard start kit.

(NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

WINDOW AIR CONDITIONER REPAIR
UNIT II

ANSWERS TO TEST

1. a. 2
   b. 4
   c. 3
   d. 1
2. a. Model number
   b. Serial number
   c. Refrigerant type and amount
   d. F.L.A. (full load amperage)
   e. L.R.A. (locked rotor amperage)
   f. Wattage
   g. E.E.R.
   h. N.E.M.A. and/or U.L. approval
   i. Btu/h capacity
3. Discussion should include:
   a. Location of data plate
      1) Top of compressor motor
      2) Side of compressor motor
   b. Information on data plate
      1) Compressor motor model number
      2) Compressor motor serial number
      3) L.R.A. (locked rotor amperage)
      4) F.L.A. (full load amperage)
      5) Voltage

        6) Phase
        7) Cycle (hertz)
        8) Horsepower
        9) Letter codes
            a) Motor manufacturer
            b) Month and year of manufacture
            c) Shift
            d) Plant

4. a. Control switch
    b. Fan motor
    c. Fan motor run capacitor
    d. Compressor motor run capacitor
    e. Thermostat
    f. Bimetal overload
    g. Compressor motor - P.S.C.

5. a. 4
    b. 5
    c. 7
    d. 8
    e. 2
    f. 3
    g. 10
    h. 1
    i. 6
    j. 9

6. Performance skills evaluated to the satisfaction of the instructor